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THE JORDAN VALLEY AND ITS LAKES

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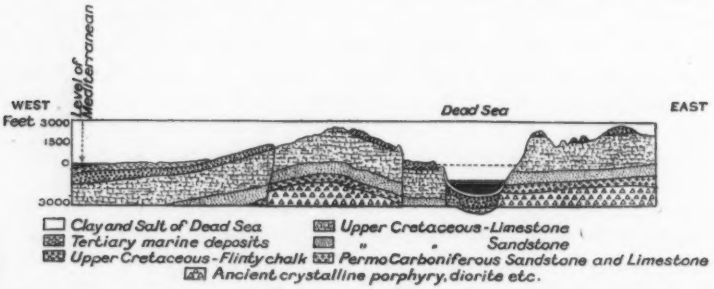
"THERE may be something on the surface of another planet to match the Jordan Valley; there is nothing on this. No other part of our earth, uncovered by water, sinks 300 feet below the level of the ocean. But here we have a rift more than 160 miles long and 2 to 15 broad, which falls from the sea-level to as deep as 1293 feet below it at the Dead Sea, while the bottom of the latter is 1300 feet deeper still." So writes the author of the 'Historical Geography of the Holy Land,' and those who pause to think of the unique physical conditions of this great rift, as well as their extraordinary association with, and bearing upon, History and Religion, will echo Sir George Adam Smith's words, "on this earth there is nothing else like this deep colossal ditch." The whole history of the Hebrews, from the days of Abraham and Lot and the Cities of the Plain, of Joshua and Jericho, was profoundly affected by this vast barrier; all through the history of the kingdoms, the times of the Maccabees, and the days of Herod, Hebrew history would have been far otherwise but for Nature's secure eastern frontier. It is needless here to recall how much of the lives of John Baptist and of Jesus were associated with this region; the pages, too, of Josephus' 'Wars of the Jews' are filled with references to this district. The Hebrews surviving the destruction of Jerusalem fled and made their stand at Masada; the Christian Jews escaping the same siege took refuge in Pella to the north. In this valley at Tiberias the scholar Rabbi Jehuda ha Nasi published the Mishna. On the Yarmuk the Byzantine Christians lost Palestine to the followers of Mahommed, and 551 years later on the western side above Tiberias the Latin Christians lost the land to Saladin. History connected with this land has been largely military history, and is by no means finished yet. Through this valley runs the slender iron track which to-day is the main source of supply for the Turkish armies in Palestine, and we may very soon see British troops fighting, as we have already read of our airmen doing, in this wonderful valley where fought armies of so many of the great nations of antiquity.

Fascinating as is the history—sacred and secular—which centres

around this region, it is not my purpose to develop it here. Were there no history and no Biblical associations connected with it, the Jordan rift would be well worth our study as a unique geographical region.

The existence of this valley is due to a great "fault" or rupture having occurred in the layers of rock during the process of their gradual elevation from their once subaqueous condition to form the mountain ranges of Western and Eastern Palestine, during the latter part of the Cretaceous or early part of the Tertiary period. This fault actually extends from Northern Syria, through the Bukaa or Cœlesyria, which lies between the Lebanon and Antilebanon, along the Jordan Valley, and ends in the Gulf of Akaba, a total distance of at least 360 miles, not counting very probable further extension through the Red Sea into the famous rift-valley in Central Africa. All along this great crack the strata eastwards have risen many hundreds of feet higher than those in the west, so that east

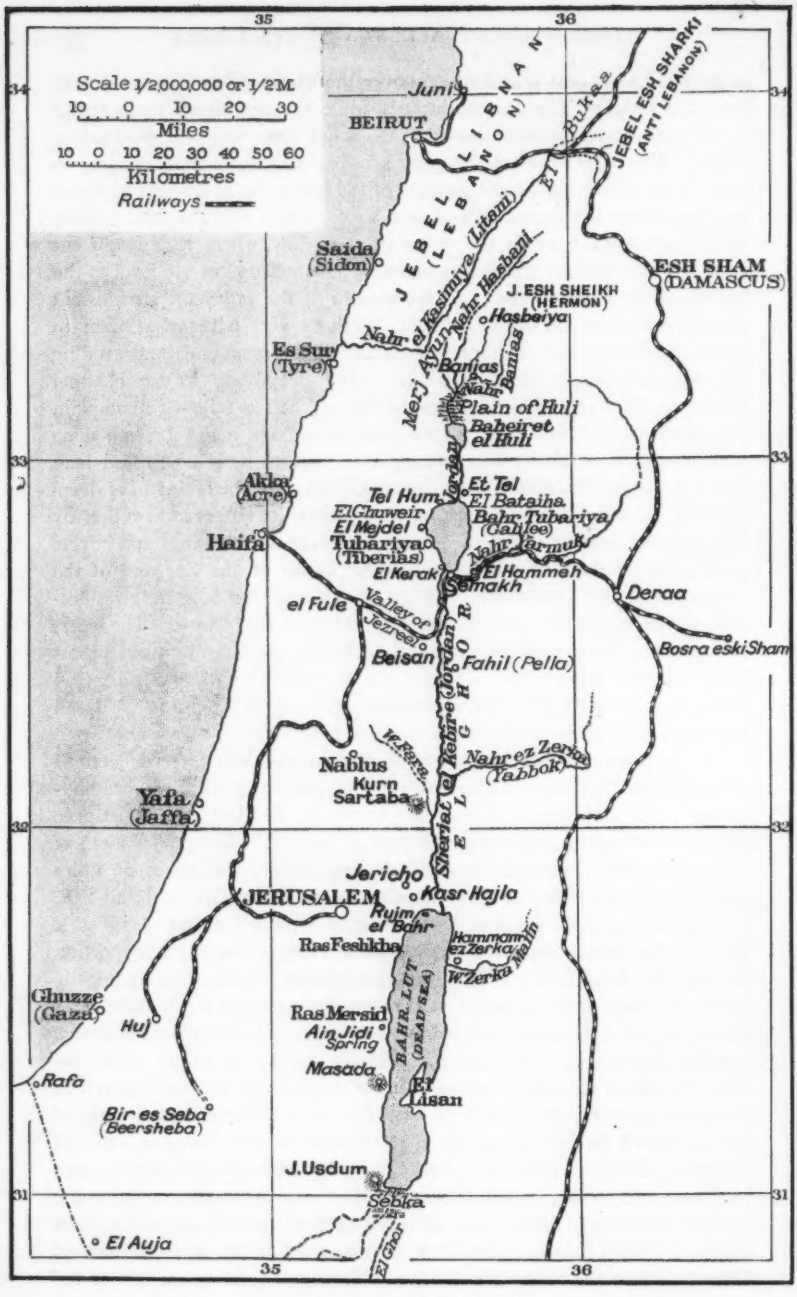


GEOLOGICAL SECTION ACROSS PALESTINE FROM MEDITERRANEAN THROUGH DEAD SEA

of the Jordan layers of Nubian and Lower Carboniferous Sandstone appear which on the west are buried deep under many feet of Cretaceous limestone. Along this line in its central part a long slice, as it were, of the crust of the Earth has dropped thousands of feet. According to some writers the whole of the Jordan Valley was once an arm of the sea—a sea now represented by the Gulf of Akaba belonging to the Red Sea—cut off from the connection with the ocean by the rising of the land towards the south. The more modern view, however, holds that the considerable height of the great diagonal ridge of limestone which now lies between the Dead Sea and the Gulf of Akaba, viz. 820 feet above sea-level, will not admit that this valley was ever connected with the ocean. Whatever may be the fact, it is certain that in the early Glacial period, at the time when the deep valleys now leading to the Jordan depression were being formed, the Jordan Valley was occupied by a vast inland sea 105 feet above the Mediterranean, over 200 miles long and 30 miles wide. The existence of such a lake is proved by the traces of old beaches at levels many hundreds of feet above the level of the lakes of to-day, and also by the vast deposits

of stratified marl and gravel which cover the whole valley to great depths from the Lake of Tiberias southwards, while the semi-fossil shells found in the high beach deposits show that the water there was only moderately saline. The outer edges of this great lake-bottom can be seen clinging to sides of the cliff in the neighbourhood of the Dead Sea at a height of about 250 feet above the present Dead Sea level. From this the lake bottom slopes downwards towards the centre of the valley, where it is deeply cut by the Jordan and its tributaries into deep channels below the level of the bottom of the ancient lake. At the mouths of the valley the streams cut through the gravelly deltas formed by these very tributaries when in earlier ages they were mighty rivers traversing the mountains and eroding the deep-cut valleys we find to-day. The deep-lying Jordan channel known as the Zor has an average breadth of half a mile—a flood-plain overgrown with reeds and brushwood—and through it the Jordan, some 100 feet across, winds its way, cutting from time to time a new bed here and there as its course silts up or becomes blocked by the falling in of deep-cut cliffs of marl. In the spring, however, when its waters are swollen by rain and the melting snows of Hermon it overflows its banks and covers great parts of the Zor with water. The banks of the Zor and of the tributaries of the Jordan are in places precipitous, and here the stratification of the marly and gravelly deposits are beautifully seen. The water channels and the streamlets produced by heavy rain have in many places worn this soft sedimentary deposit into the most weird and grotesque forms, as many travellers have witnessed in going from Jericho to the Dead Sea and the Jordan.

In the process of the desiccation of the once vast lake three collections of water have been left. In the north just above the level of the Mediterranean is the Baheiret el Kheit, also known as El Huli, and sometimes, without much claim, called the "Waters of Merom." Nine miles south of this is the Bahr Tubariya, or the Lake of Galilee; and again 60 miles further down the valley is the great salt lake the Bahr Lût, or Dead Sea. Connecting up these lakes is the Jordan, a river which has occupied a place in the world's literature and religious thought out of all proportion to its size and usefulness. The Jordan is usually described as arising by three—or four—sources, but it is perhaps more correct to describe it as formed by the junction of four tributary streams. The most famous source is at Banias, whence the stream Nahr Banias derives its name. Here the river gushes out ice-cold from the ruins of a natural grotto once sacred to Pan, and traverses in a series of cascades and rapids a tangled mass of verdure which half hides extensive remains of the once famous Cæsarea Philippi. Further south the Nahr Leddan, the largest of the sources, rises in some quiet pools grouped about a great tell which, maybe, contains the ruins of the town of Dan. The most northerly of the streams is the Nahr Hasbani, which takes its rise in a circular pool at the western foot of Hermon below the town of Hasbeiya. This river follows the line of the



SKETCH MAP OF PALESTINE

RAISED BEACHES ON EASTERN SHORE OF DEAD SEA NEAR WADI ZERKA MAIIN

LAKE DEPOSITS OF SALT AND CLAY, EL LISAN

From photographs by Prof. Ellsworth Huntington

WADI ZERKA MAIIN

JEBEL USDUM

From photograph by the American Colony, Jerusalem

great rift until it enters the Jordan Valley proper in the plain of the Huli. The fourth tributary, the Nahr Bareighit, is but a streamlet by the time it reaches the Jordan Valley, because of the diversion of much of its waters for irrigation in the Merj Ayûn.

The Jordan, known to the Arabs as Es-Sheri'at el Kebire, "the large watering-place" formed by the confluence of all these streams, after a course of only 4 or 5 miles loses itself in the great morass of the Huli. This marshy lake occupies the centre of a plain some 20 miles long and 5 broad, and is itself some 9 miles long and from 3 to 1 mile broad, though the open water is only one-third of its length. The lake in its deepest part does not exceed 15 feet and has an average depth of 9 feet. The part covered by the great floating mass of papyrus is probably shallower, only 3 or 4 feet at most. Rob Roy Macgregor, in the open water, found in the middle of the reeds a depth of 5 feet—and it is shallower now. The bottom everywhere is covered by wavy moss-like water-plants, through which in patches the white and yellow water-lilies raise their long stalks. The papyrus swamp is an impenetrable floating mass composed chiefly of the interwoven roots of these plants, but supporting in their interstices reeds, mosses, and ferns, in the midst of which many water birds build their nests. The most characteristic birds of this region are the pelican and, in certain seasons, the swan. Of quadrupeds the most striking is the buffalo, which flourishes in the marshes.

Rob Roy, in his famous canoe, made an excursion into the middle of the papyrus growth, where he found a small open lake among the reeds. In a visit I made there some ten years ago we were unable with our clumsy fishing-boat to find any open channel, and it is probable that in the interval of forty years conditions have much changed. The whole level of the lake was lowered a few years ago by artificially deepening the channel of the Jordan some distance after it leaves the lake, a proceeding which brought many hundreds of acres of sodden marshland into cultivation. Possibly this process might advantageously be further developed. As a result of this apparently, the papyrus growth has tended to creep further southwards over the open water, and the fishermen have had to restrain its growth by periodical burning of the reeds. The soil bordering upon the Huli is one of great richness, and, even under present conditions, yields plentiful harvests. Unfortunately malignant malarial fever and even Blackwater fever are prevalent. Leaving the Huli, the Jordan, about 60 feet wide, after running as a sluggish winding stream for some 2 miles, plunges downwards for another 6 or 7 miles, descending over 600 feet in one long succession of cataracts and waterfalls. From the surrounding hills glimpses of its route can be seen marked in places by great masses of oleander in bloom. The barrier between the two lakes through which the Jordan cuts its way consists largely of a thick layer of lava overlying the limestone. It descends 689 feet, in 9 miles—and most of the descent is in only two-thirds of this—a greater fall than that made by the same river on the whole

60 miles from the Lake of Galilee and the Dead Sea. As the river approaches the alluvial plain of El Bataiha, near Et Tell the site of ancient Bethsaida, its course is broken up into many mill streams, and the diminished main current reaches the lake at last by a winding course through low banks of alluvial deposit—its own delta. The Bahr Tubariya, or the Sea of Galilee, lies in a basin of hills in which volcanic rocks predominate. Along the northern shore there are two great fertile plains, El Bataiha, referred to above as the delta of the Jordan, and another delta, El Ghuweir (the Little Ghor), the fertile district known in the New Testament as Gennesaret. The ruins of the famous cities of Magdala, now El Mejdel, Capernaum, now Tell Hum, Chorazin, now Keraza, and of Bethsaida, now Et Tell, are almost exclusively of black volcanic rock, and the soil around, though enriched by limestone from the higher hills, is dark from the presence of basaltic elements. This region is plentifully supplied with water from streams and springs—many of the latter warm at the source—and is of inexhaustible richness. The warm water bordering these shores is the best fishing ground in the whole lake.

To the east and west of the lake the hills rise steeply 1200 to 1500 feet above it, leaving at most parts but a narrow plain, more developed on the east than on the west. Tiberias—occupying a small area in the midst of ruins of the Roman and Crusading cities which lay here—occupies the one broad space in the west, while to the east the cities of Gadara, Hippos, Gamala, and Aphek all lay high above, but overlooking, the lake.

The southern shore of the lake consists of steep banks of sedimentary deposits belonging to the old lake-bed, and is divided into two by the exit of the Jordan. To the west lies the hill of Kerak—almost an island—on which stood Taricheæ, an important city in Roman times. To the east the low cliffs are in part precipitous and are being encroached upon by the lake. Upon the level high ground lies the village of Es Semakh, the site of the lake railway station on the Haifa to Damascus Railway. The general view of the lake here is attractive in the spring, when Hermon towers up to the north snow-clad, the hills around are clothed in verdure, and the plains a mass of rising corn. But in the summer, though the sight of so large a sheet of clear rippling water must always be grateful to the eye amidst the intense heat, yet the bare blackness of the mountains and the almost complete absence of trees make a setting barren and austere to those who view the lake with critical eyes rather than through the glamour of history. The lake is 13 miles long and $4\frac{1}{2}$ miles broad at its greatest breadth, and the depth slightly exceeds 150 feet.

The water of the lake is clear but slightly saline—5 parts of salt to 10,000—and is peculiar among lakes with outflowing streams in the comparatively high percentage of chlorides and alkalines. This is due to the composition of the springs supplying it, which derive their salts from

the sedimentary deposits through which they flow. The region of this lake—indeed, of the whole Jordan Valley—has many hot sulphur springs. Of these the most noticeable are those of the hot baths south of Tiberias, where the principal spring has a temperature of 143° Fahr., and the air around is tainted with the smell of sulphuretted hydrogen; the springs of El Hamma in the Yarmuk Valley, which rise in several pools, some of an exquisite blue colour, amid the ruins of ancient Amatha; and the springs of ancient Callirrhœ, the Hammân ez Zerka in the Wadi Zerka Mâiin, to the north-east of the Dead Sea. Here too the water is about 145° in some spots, but only pleasantly warm in others. These three sites were all famous in Roman times for their medicinal baths, and they are still resorted to by the people of the land. Sulphur springs on a smaller scale are plentiful in many parts of the Jordan Valley, and many other springs have a constant temperature of 80° to 90° Fahr. Hot sulphur springs are popularly associated with volcanic action, and there are abundant evidences of old volcanoes and laval outflows all over the northern end of the Jordan Valley, but there has probably been no active discharge of lava anywhere in this valley for thousands of years before the dawn of history. Earthquakes seem however to centre round this region. They have been frequent all through the centuries, the cause of the destruction of most of the local monuments of antiquity, and down to quite recent times leading to great loss of life.

The Lake of Galilee has considerable variation in level in the different seasons. A number of careful observations made under the supervision of Dr. Torrance, on behalf of the Palestine Exploration Fund, shows that the lowest level is reached in October or November, and the highest—though variable—usually in the middle of April. The difference between the two is between 2½ and 3 feet. The same resident doctor has also been responsible for annual records of rainfall, temperature, etc. The rainfall is considerably less than on the coast or on the mountains—15 to 20 inches seems about the annual range. With regard to temperature, a shade temperature of 117° Fahr. has been recorded, and in the summer as high as 110° is not uncommon. The mean maximum daily temperature taken over some years was in June 94·9°, July 99·1°, August 100·1°, September 95·2°. January and February are the coolest months with a range of temperature in January 60° maximum to 48 minimum, and February 65° maximum and 50° minimum.

A tradition due to the New Testament narrators and even more to mediæval painters has associated this lake with violent and dangerous tempests. As a matter of fact, although sudden and unexpected squalls, often quite localized, frequently occur through winds blowing from the highlands down some of the valleys debouching on the lake, storms dangerous to anything but small fishing-boats are very rare. The modern boatman is very timid of risking himself on the lake unless wind and weather are favourable, and I have never heard of any boat being sunk

or any one being drowned in a storm in recent years. During the hottest months (April to November) the winds are very regular—a west wind from noon till near sunset and an east wind in the early hours of the morning—and severe storms are almost unknown. In the winter high east winds sometimes last for several days. After such a gale I have seen stone sea-walls at Tiberias demolished and the road along the lake-side washed away. On such occasions the local fishing-boats, however stoutly manned, cannot make headway against the waves. The fiercest storms, however, result from southerly winds, which after raging up the whole valley, fall upon the lake with extraordinary violence, accompanied by black rain-clouds and sheets of rain. The shores are soon blotted out in mist, and the waves may rise to a considerable height, a very real danger to fragile fishing-boats.

The lake teams with fish-life, and as all the larger fish are wholesome there is an almost inexhaustible supply of food for the neighbourhood. Of the twenty-five * species that have been described as occurring there are no less than six species of fish peculiar † to it and its springs, five more ‡ are found elsewhere only in other parts of the Jordan system,§ and three species only in other parts of Palestine and Syria. The fish of economic importance are those belonging to the Genus Chromis ‖, Family Cichlidæ—bony fishes allied to the Wrass—several kinds of Cyprinidæ or Carp, and perhaps most interesting, certainly the most conspicuous, the Catfish,¶ of the African family Siluridæ. The Chromis fish are broad from dorsum to belly and flat from side to side, and are furnished with stiff bony dorsal fins. They frequent the lake in great compact shoals, and often lie just under the surface with their dorsal fins projecting, giving an appearance like a shower falling on the water. The males of some species carry the minute young fish in their mouths, distending them so greatly that it is impossible they can get any food themselves, unless indeed, as is probable, they swallow some of their progeny. It used to be stated that the young, when they leave this place of protection, are accustomed to fly there again if they find danger at hand, but this is, I am convinced, a mistake. When they start independent existence they do so once for all.

The Catfish has a large head ornamented with prominent barbels, and attains when full grown the length of 4 or 5 feet. Average specimens are

* Several facts about the biology of the lake I owe to "A Report on the Biology of the Lake of Tiberias," by Dr. N. Annandale, *Proceedings of the Asiatic Society of Bengal*, vol. 9, No. 1, 1913.

† Varicorhinus Sauvagei, Barbus beddomei, Leuciscus zaregi, Nemachilus galilaeus, N. leontinae, Hemichromis sacra.

‡ Varicorhinus socialis, Barbus canis, B. longiceps, Tilapia simonis, T. flavi-josephi.

§ Varicorhinus damascinus, Alburnus sellal, Paratilapia magdalenæ.

‖ Tilapia (Annandale).

¶ Clarias lazera.

2 to 3 feet long. On account of the peculiar structure of their stiff arborescent gills they are able to survive a considerable time out of water—certainly many hours—and they frequently thus traverse patches of dry or marshy land. When disturbed they make a peculiar sound, which from its resemblance to the squeak of a kitten may have given rise to their name.

A small fish, attaining 6 inches long, the Alburnus scilla,* is known to the natives as Sardinnen or sardines, on account of their similarity in appearance. Attempts have been made to preserve them like sardines, but not, so far, with much success.

With regard to lower forms of life there is, without doubt, much still to be investigated. Crabs † and water-tortoises ‡ are very common. The most interesting and peculiar invertebrate is the blind prawn, *Typhlocaris Galilæa*, which is only found in one circular artificial pool of warm water on the north shore called Birket Sheikh Ali edh Dhaker. I frequently saw this creature lying upon the weeds of the pool long before it was described, and had little idea that I was looking at a then quite unknown species.

After leaving the lake the Jordan enters upon its very winding course of 185 miles to the Dead Sea, a clear stream; there it ends its course with its waters loaded with sediment. It runs, as has been mentioned, in a deeper valley of its own—the Zor—worn out of the old lake-bottom, where it wanders from side to side, here washing up against precipitous cliffs of sedimentary deposit, there spreading itself out amongst rocks and islands, and everywhere surrounded by a tangled mass of tropical trees and shrubs—tamarisks, willows, oleanders, poplars, thorny acacia (sidr), bamboos, etc. Some 4 miles south of the lake it receives the important tributary, the Yarmuk from the east, and 9 miles further on the valley expands opposite the town of Beisan, ancient Bethshan and Scythopolis, and the opening of the Valley of Jezreel. Here the Jordan plain presents peculiar features to the west. First there is the plain on which Beisan stands, some 300 feet below the level of the Mediterranean, which presents an unbroken slope westwards to the valley and the mountains. Passing east from Beisan there is an almost precipitous drop of 400 feet to the general level of the Ghor, and still further east another drop of 150 feet to the Zor—here a valley from a quarter to half a mile wide. On the eastern side a little south of Beisan lies Fahil—the site of Pella. From this district the Jordan runs for 12 miles through a narrow valley 2 or 3 miles wide, with a plateau 500 feet above sea-level to the west. Further south the valley widens considerably by the confluence of the Nahr ez Zerka (the Jabbok) on the east, and the Wadi Fara on the west, and just

* Alburnus sellal, Hekl (Annandale).

† Potamon potamios.

‡ Clemmys caspica rivulata, Emys orbicularis.

beyond stands up that remarkable landmark Kurn Sartaba, which rises 2400 feet above the Jordan and 1644 feet above sea-level. It is visible from almost the whole extent of the valley. Beyond this the Ghor widens considerably—to over 10 miles; the Zor also becomes more marked. When opposite Jericho the sloping plains on the two sides of the river together are 14 miles across; and the Zor, 200 feet lower, is a mile across.

The heat, which is very trying at Tiberias, is greater still in the lower Ghor. Temperature observations made at Kasr Hajla (between Jericho and the Dead Sea) show that from May to October the mean of the maxima temperature is 112·5°, the mean of the minima 91°, while in the cooler six months the figures are 101·5 and 74·3 respectively.* Most of the Ghor is no fit place for habitation by Europeans; malaria and the local variety of oriental sore known as the Jericho boil are both prevalent. During all its long and very winding course within the Zor, a distance of near 200 miles, the Jordan is full of rapids. According to the explorer Lynch, there are "no less than twenty-seven which entirely stopped navigation and many others that rendered it very difficult."

The Dead Sea is the most interesting of all the geographical features of this valley. The unique depth of its surface, 1292 feet below the Mediterranean, has been already referred to; its further depth of water is considerable, actually reaching nearly 1300 feet in some places. It is about 47 miles long and 10 miles broad at its widest, and its total area is calculated at about 300 miles; it is divided into a northern two-thirds where the water is deep, especially on the east side, and a southern bay of variable extent and depth, but nowhere over 30 or 35 feet, and much of it quite shallow. The division between these two is a peninsula known in Arabic as *el Lisan* (the tongue), which runs out from the eastern shore halfway across the lake. In outline it is like a boot with the toe pointing north. The seaward aspect of this peninsula consists of cliffs of soft marl, about 20–30 feet high, and north and south it ends in two points, Point Costigan in the north and Point Molyneux in the south. [These names are given on the War Office map 1/250,000; but it is to be hoped that they will not come into general use, as they violate elementary rules of geographical nomenclature. ED. *G.J.*]

The northern and southern shores of the Dead Sea are more or less flat. The former has a pebbly beach, behind which there are in places lagoons and creeks which go some way inland. At a few spots there are brackish springs, which nourish green patches of reeds, tamarisks, and sidr trees. Where the northern shore approaches the western mountains there is a considerable oasis of several springs and some miles of reeds. This district is known as 'Ain Feshkha, and is one of the most fascinating

* 'Studien über das Klima des Jordantals.' Von Prof. Max Blanckenhorn, Sonderabdruck aus des Z. des D. Palästina-Vereins.

spots on the seashore. Along the western border of the Dead Sea the mountains fall steeply to the water at several places, noticeably at Ras Feshkha and Ras Mersid. At many other places there are springs or streams, with a luxuriant vegetation almost hiding their waters. At such spots small delta-plains have been formed. The most famous of these springs is Ain Jidi—the fountain of the kid—a cool spring of fresh water which rises on a small plateau some 300 feet above the Dead Sea, and which once sustained here a great region of verdure. To-day for want of proper distribution of the water most of it runs to waste.

Between Ain Jidi and Masada (Es Sebbe) there are 10 miles of broken ground 2 miles wide between the mountain and the shore, which is intersected by numerous wadis. The great precipitous rock of Masada, now called es Sebbe, is at once the most striking and the most tragic historical monument on the Dead Sea shore. It stands out with almost precipitous sides 2000 feet above the sea, and from it a magnificent view of the sea and especially of El Lisan is visible. Whatever the impressions produced by these natural features, no one knowing the history of this spot can stand here unmoved. In this natural fortress, converted nearly a hundred years previously by Herod the Great into a walled and munitioned stronghold, the last wretched remnants of the escaped Jews from Jerusalem held out for many months against all the might of Rome, and finally preferred to seek self-destruction to falling into their enemy's pitiless hands. Still further south, at indeed the south-west corner of the lake, lies the strange mountain of salt, Jebel Usdum, the mountain of Sodom. This is a high hill rising 500 feet above the level of the Dead Sea, and running for 7 miles along its shores. The great mass of the hill is of the same marly substance as the rest of the sedimentary deposit in this valley, and identical with that composing El Lisan, with which it is supposed it was at one time continuous. Under this, rising from about the Dead Sea level to about 100 to 150 feet, it is a mass of crystallized rock salt. In many places the salt is hidden and overlaid by marl, but in other parts furrows and caves have been made by water-action, and the salt is exposed in beautiful and complicated forms. In the cave grottos there are stalactites and stalagmites of greenish semi-translucent salt, and in the furrows the salt has been scored into intricate shapes of all kinds. As it was raining when I was there we lunched in a strange salt grotto among these beautiful and weird crystal forms. We could not get south to the well-known larger cave described by many previous travellers, because the road which once ran at the foot of these salt cliffs has now in recent years become submerged by the rising of the Dead Sea, and a boat is necessary to approach the cave. This great mass of salt must result from the desiccation of a body of salt water. This process must have occurred before the deposit of the great lake-bottom, to which reference has so frequently been made.

The south end of the lake is occupied by a vast mud-flat known as the

Sebka. The water here advances and recedes over a considerable area, and the ground for a great distance shorewards is so treacherous that a *détour* southwards is necessary for those who would cross to the eastern side. At the south-east corner there is an oasis of tangled thorny trees and plants and some brackish springs known as Ghor es Safiya.

As regards the eastern border, the Dead Sea is almost unapproachable northward from El Lisan. At the mouths of the wadies there are small delta beaches with palms growing, but these can hardly be reached from the land side; on most of the eastern side the cliffs rise almost sheer 100 feet or more from the water. There are two notable spots—both only to be reached by boat—at the mouths of the Wadi el Mojib or Arnon and the Wadi Zerka Maiin. There the rivers have cut enormous rifts of almost perpendicular cliffs, and, as the rocks consist of coloured sandstone, the aspect is most beautiful.

The waters of the Dead Sea are impregnated with salt to an extraordinary extent, but varying very much in places. At the northern end the percentage is 24 to 33 per cent., or five times as much as the open ocean, which has 3·6 to 4 per cent. solids; but in the southern bay the waters are actually saturated and salt crystallizes out on the bottom. The main ingredients are chlorides of magnesium and sodium—the latter the common salt of our tables—but there are considerable quantities of calcium and potassium chlorides and traces of bromides and iodides. These latter do not exist in sufficient percentage to admit of successful commercial exploitation.

The extraordinary saltness of the Dead Sea has been ascribed to three causes: (1) That its waters were once connected with the ocean, and that this water—salt at the time—has been concentrated by evaporation. This is very doubtful. (2) That the salts are derived from the erosion of rock, and the concentration of the vast amount of water impregnated with soluble salts in this way by the enormous evaporation that has been going on for untold ages. And (3) that the atmospheric transportation of salt from the Mediterranean has been a very important contributing factor, if not the chief one.

Salt is a monopoly of the Turkish Government, and armed guards are kept during the summer months among the lagoons of the north shore to prevent smuggling. They are withdrawn in winter, and smuggling occurs with little attempt at secrecy. The Arabs collecting the salt plunge into the lagoons and bring up the masses of salt from the bottom with their hands, often having to submerge their heads as well as their arms in the process. Even when obtained in this primitive way and packed away in sacks the smugglers have a risky task to escort their gains into the mountains through the dangers of the military police and the destructive effects of heavy rain. I have travelled some miles from the neighbourhood of the Dead Sea to about halfway to Jerusalem with a party of these Bedawin, who were friendly enough when they saw I was only a foreigner. They were

MASADA

From photograph by the American Colony, Jerusalem

RAISED BEACH, SHORE OF DEAD SEA

SALT SMUGGLERS

OBSERVATION OF SEICHES, SEA OF GALILEE

escorting half a dozen camels and seventeen donkeys. I can assure you they often have an exciting time; if detected not only their salt is confiscated but also all their animals. Asphalt is also claimed by the Government. Small fragments of this substance can be found almost everywhere along the beach, but not infrequently the Arabs find masses of several pounds' weight, and at times—especially it is said after earthquakes—huge masses,* large enough to support the weight of a great number of human beings, have appeared floating on the Sea. It has not yet been definitely ascertained where these deposits lie; and hitherto the Sultan of Turkey, who claims great rights in the Jordan Valley, has discouraged all attempts to scientifically explore the deposits. It is quite possible petroleum deposits may yet be found in this most interesting region. Travellers going by boat along the eastern shores have reported the occurrence of petroleum upon the surface of the water in places.

Until quite recently the Dead Sea had no boats on it. Some years ago the Greek Patriarch, at great trouble and expense, had a small steamboat conveyed from Jaffa and launched on the Lower Jordan to take excursions on the lake. One celebrated trip was made to which many Consuls were invited, and then orders came from Constantinople that permission to navigate the Dead Sea was refused, and so the boat remained held up in the Jordan for some years, and was finally, I believe, transported back to Jaffa. At rare intervals adventurous travellers and explorers brought boats here, *e.g.* Costigan, Molyneux, Lynch, and several more recent travellers, but up till the war the only permanent boat was a small sailing ship—built on the shores—which used to run from south-east to the north shore with grain from the Kerak district. We now learn that there are a number of boats, including at least one motor-boat, brought from Jaffa, engaged on the transport of grain and munitions of war from the east across the Dead Sea for the use of the Turkish Army.

One of the most interesting problems in connection with the Dead Sea is the question of its varying levels during (1) Prehistoric times, (2) Historical times, and (3) during the Seasons. I have myself been particularly interested in this last, but incidentally also with the second. An assertion was made many years ago, I believe originally by the great American student of the Holy Land, Dr. Robinson, that the difference between the summer and winter level of the sea was 15 feet. This statement was repeated unchallenged for many years and even to-day is quoted in articles on the Dead Sea. Some eighteen years ago the late Sir John Grey Hill, in an article in the *Quarterly Statement* of the P.E.F., threw doubt on this, and in consequence the Committee of the Fund proposed to me that I should make some regular observations to ascertain the actual facts. Such a proceeding may sound simple, but in a region where there

* Burkhardt, 'Syria,' p. 394; Robinson, B. R., [illegible]; Lynch, Narrative, 303, etc.

are no dwellings or permanent inhabitants, when the climatic conditions are trying and the distance from Jerusalem not inconsiderable, and where the Arabs (Bedawin) would certainly put all possible difficulties in the way, required some planning. The simple way would have been to put a post, of wood or metal, marked in feet and inches somewhere near enough to the shore to be easily visited, but our experience of these lawless people made it certain that any such effort was foredoomed to failure; the mischievous and suspicious Arabs would certainly have uprooted or otherwise defaced such a record even if they did not, as was probable, carry off the post itself. When on one occasion I had made a mark on a great accessible rock as a second observation place, I found on the next visit that these people had gone to the trouble of blowing it off with gunpowder. There are many spots where steep cliffs descend sheer to the sea-level, but almost all such places were so distant from Jerusalem—and so insecure in many cases from Arab robbers *en route*—that either a considerable expedition or a boat would have been needed on every visit. Finally, however, in conjunction with Mr. (now Prof.) R. A. S. Macalister, I made a visit to 'Ain Feshkha, and after traversing the length of the oasis and doing some stiff climbing along the shore over masses of fallen rocks, we found a great uptilted boulder of conglomerate rock standing sheer out of the sea to the height of some 25 feet. Here we had a line cut at a spot convenient for dropping a tape measure, a distance on that day of 14 feet, to the surface of the sea. At this spot I made a series of measurements which I think have settled the question of the annual changes of level once for all. The first two and a half years I made, or arranged to be made, nineteen visits, and in this way we found the times of the normal highest and lowest levels. The former occurs about the middle of April—when the winter's rains are just over—the latter during November when the actual winter's rainfall begins. Since then, with the exception of one season when I was away from the land, records have been taken regularly, so that we have an almost complete chart of the seasonal rise and fall for 1900 to 1913 inclusive. It is evident that the extent of the rise is directly affected by the rainfall—the amount and the length of the rainy season. The highest rise in one winter occurred in 1905–6, viz. 3 feet, after a season's rainfall, as measured in Jerusalem, of 39 inches, following a previous winter's fall of 37·32 inches. The smallest rise (1903–4) was 8 inches following a rainfall of 21 inches, preceded by a rainfall of 26 inches. The mean rise of eleven seasons was $21\frac{1}{2}$ inches and the mean fall over twelve seasons was $23\frac{1}{2}$ inches—almost exactly 2 feet.

The effect of two scanty seasons is very marked because of the great diminution in the output of the springs. This was noticeable in the 'Ain Feshkha district itself, but could be confirmed all over the land. It is true that our rainfall observations were only in one place, but observations in other parts showed that on the whole diminished rainfall on the mountain-tops was accompanied by the same phenomenon in the plains. Other

factors which undoubtedly influence the extent of the rise and fall are —(1) the amount of snow precipitated upon Hermon, a factor which will depend upon the temperature as well as the rainfall. The melting snow reaching the Jordan and Dead Sea late will delay the onset of the fall and therefore the extent. (2) The temperature of the air in summer. Greater heat, and especially greater prevalence of the dry Sirocco or desert winds will increase the amount of evaporation, which amounts to millions of cubic feet *per diem*.

Besides the annual variation, even this short period of observations gave evidence of periodic changes of level. The dry seasons between 1901–1904 here produced a gradual fall which was succeeded by a rise during the unusually wet seasons 1904 to 1906. The difference between the highest and the lowest measurements during the whole series of observations was about 6 feet. There is an accumulation of indisputable facts showing that there has been, on the whole, a very considerable rise in level during the nineteenth century—a rise which, as far as the rain records at Jerusalem go back (*i.e.* to 1860), has been accompanied by—and as I believe caused by—a steadily increasing rainfall. The evidence for the rise is fourfold :

(1) At many points dead trees are visible some distance from the shore, their roots now submerged some feet deep.

(2) Up to 1901 a small island, Rujm el Bahr, was visible off the north shore of the Dead Sea. From the records of travellers we know that in the earlier part of last century the Rujm el Bahr was a peninsula which could—at any rate at times—be approached dryshod (Lynch, 1848). In 1850 the peninsula became an island, to which it was possible to ride on horseback through shallow water (De Sauley, 'The Dead Sea,' 2, p. 53, 1851; Tristram, 1858); a few years later it was necessary to swim out to it (Tristram, 1864); and in 1892, after an unusually heavy winter's rainfall, it disappeared altogether. It is impossible now to locate the situation of this rocky mass without soundings.

(3) Until recent times there was a regular road between the salt cliffs of Jebel Usdum and the sea. Thus Hull in December 1883 traversed the shore at the base of the salt cliffs "along a gravel terrace 100 feet wide which abruptly terminated in a descent of about 5 feet to the line of driftwood which marked the upper limit of the waters." For some years past—at least since 1892—this has been submerged, and the sea reaches the foot of the cliffs for a considerable distance. At the same time the waters of the Dead Sea have been observed to have extended a great distance further south over the Sebka.

(4) We have evidence that at the beginning of last century it was possible for Arabs,* with their donkeys and camels, to cross from the eastern to the western shore through the shallow waters of the southern bay of the Dead Sea. They followed a causeway marked out by stakes from El Lisan.

* Burchhardt, 'Travels,' p. 364. Irby and Mangles in 1818 ('Travels,' p. 454).

The tradition of this survives to-day, but it is eighty or ninety years * at least since the level of the sea allowed it.

But beside the fact of the use of the level—on the whole—during the last century we have before us on the shore of the sea equally clear evidence of higher levels. Besides the minor seasonal variations, which are marked by ridges on the shingle beach which can be traced for considerable distances some feet above recent levels, we have inland from this a complicated system of "raised beaches." Thus on the north shore at many places will be found (1) the beach with several layers of shingly ridges, and highest of all a thick deposit of dead drift-wood. Behind this will often be lagoons of salt water, and then the ground rises to a compact and consolidated ridge which can be traced, running roughly parallel with the present shore, for miles. Behind that the ground will again be lower and then rise to a still higher ridge, and so on. The lowest of these consolidated ridges I made out to be by direct measurement 20 feet above the present sea-level, but Prof. Huntington, who came to the land largely to pursue investigations on this point, considered that he had traced beaches at 12, 30, 40, 50, 56, 70, 90, 115, 145, 170, and 210 feet; and above that again were great abandoned shore-lines of which the most famous and certain lie at 250, 450, 650, and 1400 feet above the present level. This last, by common consent, represents the conditions prevalent during the glacial period (Huntington). It was at the time of these higher levels that the enormous deltas were deposited which can be still seen, deeply scored and eroded, at the mouths of some of the larger valleys. It is therefore quite certain that the level of the Dead Sea has varied very greatly. The highest levels belong to the period of the Great Sea, which once filled the whole valley, and the next highest marks the gradual, or perhaps periodic, drying up of this mass of water in prehistoric times. It is, however, a question of interest whether some of these lower beaches—all, Prof. Huntington thinks, below the well-marked 250-feet line—may not have belonged to the historic period, and mark, he argues, periods in not distant history when the land had a cycle of rainfall greater than any it has had for a long time. It would be a matter of great interest if we could in some way date some of these lower beaches. I have myself, during the short period I have made regular visits to this region, seen so many changes in the shore, especially in the 'Ain Feshkha region, that I can well believe that conditions on the Dead Sea shore may have very greatly varied during the centuries. Another factor which must have greatly affected the condition of the north shore has been the gradual encroachment of the Jordan delta, which must have largely contributed to the shallowing of the sea and the extension southward of the land in this part. The amount of sediment brought down by the muddy Jordan is enormous, and one geologist (Wright) calculates that the Jordan delta has within the historic period encroached upon the sea to an extent of 15 or 20 square miles. This of course would in itself tend toward raising of the level. M.

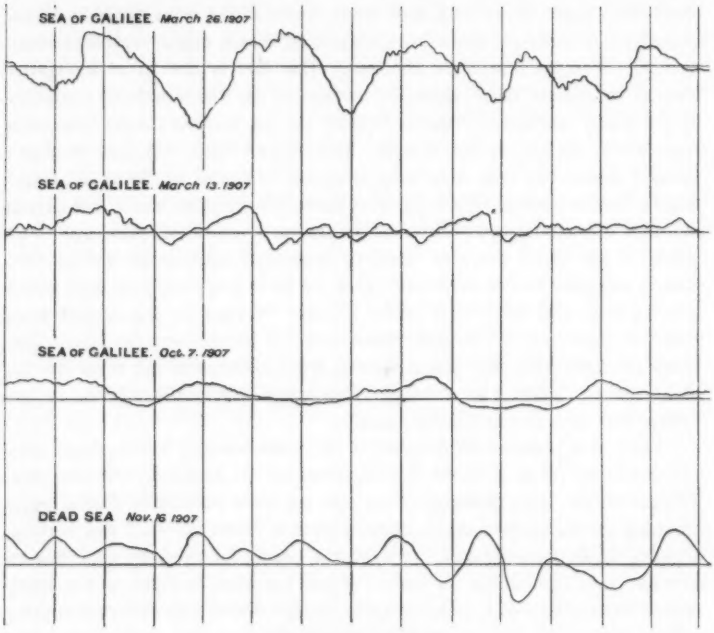
* It was impassable in 1838—Robinson.

Clement Gauneau (*Q.S.*, 1904, p. 167) argues from historical and archæological grounds that, as the Dead Sea must have extended northwards to the Beth Hogla, the level of the Dead Sea must have been 300 feet higher than it is at present at the time of the writing of the Book of Joshua, but if the extension of the Jordan delta be taken into consideration, there is no need to calculate such a great amount of difference in level as this. Huntingdon considers a level only 70 feet above the present one would be enough. During my many visits to this interesting region I had opportunities of making many minor observations. Travellers in past years have reported a curious "white line" which is visible at times running north and south down the centre of the sea, and many speculations were made as to its cause, one divinity professor even suggesting that it might represent some existing rift in the bottom of the sea. This line is due to an elongated mass of compacted foam which, on account of the dense and oily character of the Dead Sea water, remains floating on the surface longer than such foam would remain on the ocean. During east winds this line is blown steadily across the lake in a long irregular line, and on many occasions I have seen it washed up on the west shore. With other winds it is driven in other directions, and with a rough sea it is entirely broken up. The winds in the Dead Sea area seem to commonly take, under normal condition, a regular course each day. N.E. or E. in early morning, S.E. about 9 or 10 a.m., and N. or N.W. about 5 p.m. Writers on the subject have frequently referred to the mist which they say hangs over the sea. This is so at times when the sea is viewed from above, but not when on the shore itself. Then the atmosphere, looking across the sea, is, in my experience, as a rule brilliantly clear.

There is a peculiar disturbance of the water which I have noticed, and which was, so far as I know, first reported by an American traveller, Mr. Putnam Cady. This observer states that on three successive nights, while camping on the eastern shore, about 7.30 p.m. when no wind was stirring, a heavy breaker came pounding upon the beach, followed by a succession of other waves for about an hour. When spending a night at the north end in November, 1913, I heard across the sea about 8.30 an extraordinary rushing sound, like waves breaking on the eastern shore, and a little over an hour later long diagonal waves running towards the south-west—a recoil apparently from those which had been running east—visited us and pounded away until 1 a.m., although there was scarcely any breeze and that from the north. This wave disturbance must, I think, be due to the rapid change of temperature which sets in shortly after sunset. At least, I have no other theory to account for it.

Some years ago, at the suggestion of the late Prof. Chrystal of Edinburgh University, who kindly sent me the necessary apparatus, I undertook to make some observations upon the phenomena known as seiches in the Jordan Valley lakes. These observations are so incomplete that I can only bring the records forward now as tentative results. As Prof.

Chrystal has now passed away, I venture to bring them to the notice of this Society, as they may be of interest to those who have made a study of the subject. Seiches have been very thoroughly studied on Swiss Lakes, notably at the Lake of Geneva, and more recently by Prof. Murray and Prof. Chrystal on the Scotch lochs. It is generally accepted now that seiches are periodic changes in level of lakes due to oscillations of the water as a result of variations in barometric pressure. While the level of the water at one end of a lake rises rhythmically, that at the other end falls correspondingly. The amount of the rise and fall and the rhythm depends



SEICHE RECORDS

The vertical lines mark intervals of five minutes

upon the length, depth, and shape of the lake, but in every lake depends upon barometric conditions. At one time a seiche may be of considerable amplitude—some inches, even very rarely feet—at other times no seiche can be detected. Elaborate methods of recording seiches have been installed in favourable situations, but under the conditions in Palestine—especially at the Dead Sea—my preliminary observations could only be made by a portable instrument. This consisted of a tank—like a long bucket—which was sunk in the shingle near the sea margin, a long, stout indiarubber tube connecting the water in the bucket with that of the sea

by running under the shingle some feet out into the water, a float which when resting on the surface of the water in the bucket was connected by means of a silk cord with one handle of a lever, while the other end of the lever was furnished with a pen for recording the level of the water on a revolving drum. Every rise of the water causes the attached arm of the lever to go up and the recording end to mark a descent on the drum, and *vice versâ*.

At the Lake of Galilee I made at intervals three records of several successive hours, and, as will be seen, the appearances presented vary much, but under favourable circumstances very marked seiches occurred.

Prof. Chrystal was curious to know whether in waters as dense as those of the Dead Sea seiches would occur, and if so of what character. The difficulties of taking seiches there—without a fully equipped scientific expedition—were considerable, and on one occasion I failed to obtain any evidence at all of a seiche. My observations were several times interrupted by the splashings of heavy waves, and I have it recorded on occasions that my toy apparatus tumbled headlong into the sea. I have, however, evidence that here too seiches occur, not apparently as high as those in the Sea of Galilee, nor, in my experience, with such regular rhythmic succession, but enough to suggest that we have here a field of research which, when Palestine is once again a land of peace and quietness—under we will hope a more civilized government—it would be worth fully investigating. We ought, too, to have full information with regard to rainfall, temperature, and barometric pressure. My efforts to get one of the native hotel proprietors at Jericho to look after a rain-gauge —which I, at the request of the P.E.F., placed at his disposal—ended somewhat comically. When some weeks later I found nothing had been recorded, I was on expostulating asked in all seriousness, "I don't quite understand. Do you want me to put water in this vessel?" Further explanations led to no better results. On a later visit I found the gauge very carefully locked up, and I finally transferred it to Jaffa. Some rather doubtful and incomplete observations of a winter's rainfall at Kasr Hadjla in the rainy season 1905–6 give the season's fall as about $7\frac{1}{2}$ inches (Blanckenhorn, *loc. cit.*).

With regard to temperature, my own visits have been made as far as possible at times usually early morning and at night and in the spring and autumn, and consequently I have no extraordinary records, like those referred to previously. The mean of several spring visits was 76·5°, and of visits in October and November was 81·0°, but this latter on the shores of the sea where the atmosphere was very humid, was often very oppressive.

Ancient writers established a myth that the Dead Sea was an abode of death, that its shores were sterile, and that even birds flying over its waters were liable to fall dead. All these ideas we know to be the reverse of the truth. It is true that the water of the Dead Sea is so permeated with salt—the actual amount varying greatly according to the locality—

that no animal or vegetable life can flourish in the bulk of its volume. Near the shore where streams of brackish water find their way into the sea, small fish, crabs, and mosquito larvæ are found. I have myself seen fish in the sea, not only off 'Ain Feshkha, where fresh water not only runs from the shore but there are submarine springs, but also at the well-known spot on the north shore where travellers resort. I confess that I could hardly believe my eyes when I saw a number of small fish—almost certainly the species known as *Cyprinodon dispar*—darting about in the water near the shore. I was able to call two reliable witnesses to confirm my statements. A bottle of water taken from the same spot immediately afterwards proved on examination by Mr. Purvis, of the University of Cambridge Chemical Laboratories, to contain no less than 33·3 per cent. of solids.* In one of the Jericho hotels there is, or was before the war, a declaration jointly signed the same year by over a dozen tourists that they saw fish actively swimming at the same spot. The observation that fish can, under favourable circumstances, find their way along the northern edge of the sea will account for the fact that while fish abound in the springs and many of the pools between the Jordan and Ras Feshkha they are absent from the springs further south.

At many spots along the shore there are oases in which acres of reeds and many trees flourish—'Ain Feshkha is one of the largest of these. At such spots animal life is abundant. The most characteristic animal is the coney (Hyrax) that exists in great numbers on the rocks around—I have seen them many times, and their burrows are everywhere. The ibex, which lives at a higher level, is not uncommon. The gazelle and jerboa are common on the neighbouring plains. Jackals and hyænas prowl about at night. I have several times seen their footprints, as well as that of the wild boar in the Feshkha district. Bird life is very abundant. Sand and rock partridges are always seen. Tristram's grackle, quail, grouse, large owls, storks, flamingoes, hawks, wild duck, rock and wood-pigeons, and many kind of small birds I have at times seen.

While it is true that without the great Jordan rift the whole history of mankind must well have been very different, it is emphatically true that it is this which makes and has ever made Palestine geographically a unique land. From a thousand points of view it is this great rift which gives picturesqueness to the land. The great range of Moab's mountains, in all their changing colours, and the marvellous and mysterious panorama of the great stretch of wilderness and lake and mountain from the Mount of Olives are the chief points of beauty from Jerusalem; and nearly all the scenes in the land which most dwell in memory are those in which some part of that great cleft dominates the view. And perhaps the Dead Sea itself with its lofty mountains is the most beautiful of all things in the land. The visitor looks for sterility and death and he finds a lake of ever-changing colours and varied movements and plenty of life at many a point, set in

* See *Q. S.*, 1908, p. 95; also p. 160.

the midst of majestic mountain chains where, if viewed from the lake-side, every valley stands out with a brilliant clearness. I shall never forget the exhilaration of the rides before dawn across the Jericho plains, the brightening light and ever-changing cloud effects as the light strengthened, until at last the sun commenced to pour its hot rays over the summits of Moab. But even more do I recall the brilliant moonlight nights when on the Dead Sea shores one watched the distant wavelets like rows of diamonds in the reflected moonbeams. One recalls baths taken long after sunset in the waters so warm that it was a shock to raise one's body into the gentle breeze. I am not traveller enough to know what sites are its rivals, but I venture to say that to most people who can combine into one the romance of history, of science, and of beauty the Jordan Valley must ever remain a region apart—absolutely unique upon this globe.

Before the paper the PRESIDENT said: Our eyes lately have been turned very much in the direction of the Holy Land, and our thoughts must often have been with those who so recently had the extraordinary privilege of spending their Christmas at Bethlehem. Therefore it is with the deepest interest that we shall listen to what our old friend Dr. Masterman has to say about the sacred Jordan, that extraordinary river, unique in its historical associations and also in its geography.

(*Dr. E. W. G. Masterman then read the paper printed above, and a discussion followed.*)

The PRESIDENT: We have had a delightful address from Dr. Masterman, full of interesting detail, and I must congratulate him on the excellence of the photographs which he has shown, which have brought home to us the scenery of the Jordan and its surroundings in a way nothing else could have done. Out of such an address many points of great interest arise. I will call first on Mr. Zangwill.

Mr. ISRAEL ZANGWILL: When Dr. Masterman referred to Masada he said how wonderful it was that the Romans should have been enabled to send an army to this sterile rock and defeat the Jews there. I thought that a wonderful topsy-turveydom. The wonder to me was that the Jews should have been able to sustain themselves there for two years. That was not really the end of the Jews, because a couple of centuries afterwards there was a further revolt. I do not know whether it is right to talk about anything but geography here, but the really interesting thing is how the Jews came to fight against Rome. The reason was, as the master theologian told us, their absolute faith in their being the Chosen People and having God on their side. They had already seen so many great empires dissolved, that they thought there was no possibility of Rome being able to conquer them. They had held out so thoroughly against the Greeks and the culture which tried to overwhelm them several centuries before that they made a Feast called Chunucha. After two thousand years Jerusalem has fallen on the very eve of that Feast, and the city has now been promised to the Jews, which is an extraordinary example of their holding out in history. My remarks are all tending to be non-geographical. The utmost I can do is to say that from the pictures we have seen, Palestine is not a place overflowing with milk and honey. It really never was: it was all artificial irrigation. And if it does not flow with milk and honey now, it is owing to the

mis-rule of the Turk, whom I call the Lord of Mis-rule. Whatever one may think of Imperialism, one must admit that there cannot be any natural right of the Turks to go on holding a country which they have mis-ruled so long. My other claim to speak consists in the fact that although I am not a geographer I have helped to strengthen the cause of geography in others. While it seemed quite impossible that the Jews should have any chance of getting Palestine from the hand of the Turk, I occupied myself in a movement for looking round the world, to see if there was any other possibility of a land in which the Jews could form an autonomous State. There appeared to be many possibilities, but only two which seemed worth investigating. One was Cyrenaica, which was examined by a brilliant member of this Society who is now in India, Prof. J. W. Gregory. I had the honour of sending him out with an expedition to Cyrenaica, and after that there was the expedition to Angola, which Prof. Gregory also undertook. Upon this I pride myself, as giving me some claim to a place in the geographical world, though I have little to say about geography. If I said anything more at all, it would be to tell you how extraordinarily happy the Jews are, to think that they will form part of the great British Empire.

Prof. LEONARD KING (Chairman, Palestine Exploration Fund): The Palestine Exploration Fund is peculiarly interested in the subject of the lecture. Dr. Masterman's are the only observations on the varying levels of the Dead Sea that have been carried out systematically and over a period of years. They were undertaken in the first instance at the suggestion of our Executive Committee, and the results have been recorded regularly in the pages of the Fund's journal. I think Dr. Masterman is to be congratulated on the perseverance and ingenuity required to obtain results under the difficult conditions prevailing in Palestine before the war. We hope that he will be able to continue his researches in the future under more favourable circumstances. The figures he has given for the difference between the summer and winter levels of the Dead Sea demolish an accepted opinion by proving that the average difference is much less than 15 feet. He has shown that over the period of years during which his observations have extended it is really less than 2 feet, and I should like to point out that that has an important bearing on at least one problem connected with the future prosperity of Palestine: the uses to which the water of the Jordan Valley may in future be put. The figure at one time accepted for the seasonal rise and fall of the Dead Sea is related to another figure widely held with regard to the amount of water received daily by the Dead Sea, which in modern works of reference, including the latest edition of the *Encyclopædia Britannica*, is put at no less than six million gallons. But that statement is made with equal confidence in books that appeared before the publication of Dr. Masterman's researches. Though I have not yet traced it to its source, I venture to think that the two statements are really interconnected, and if we reject the one we must suspect the other. But even if we must disregard that very optimistic figure of the daily supply to the Dead Sea, there is, I think, no doubt that a large quantity, drawn in great measure from perennial sources, is still running to waste in the Jordan Valley as in the rest of Palestine. I will give one instance to illustrate the latter point. Most travellers who have passed through Beirut or visited the Nahr-el-Kelb have made the acquaintance of Mr. Martindale, for many years before the war the very able head of the Beirut water-works. Some years ago he was asked by the Turkish authorities to visit Ras-el-Ain to the south of Tyre, and report on possibility of the water supply. That suggestion was probably due to the fact

that the famous plain near the springs was the private property of the late Sultan, Abd-ul-Hamid. I forget the figures he obtained as the result of his test, but I believe the daily output of each spring was between two and three million gallons; and in the opinion of Mr. Martindale the force of water at the head would suffice to develop a considerable amount of power in addition to supplying the city of Tyre with water and irrigating a great part of the plain. But after turning a couple of mills, most of the water, I believe, is still running to waste into the sea. That is typical of conditions in Palestine generally, and of the Valley of the Jordan in particular, for there the possibilities of water-power are obvious in view of the very great fall in the valley from end to end. And this also applies in some degree to the more important tributaries such as the Yarmuk, and in a lesser degree to certain of the smaller streams such as the Wadi Fejjas. This comparatively short wadi, which drains the Sahel-el-Ahma, falls into the Jordan from the west, to the south of Lake Tiberias, and in antiquity by means of an aqueduct supplied the city of Tiberias with drinking-water and turned a large number of mills, of which only the foundations now remain. In conclusion, it seems to me this question of water-power is of very great practical value in any plans that are made for the future of Palestine, in view of the fact that great areas are unsuited for irrigation. Under those circumstances if you have cheap water-power that can be conveyed to different parts of the country in the form of electrical supply, then the establishment of skilled industries would be encouraged, and the population which the country can support would be considerably greater than if reliance was placed upon agriculture alone.

Colonel C. E. YATE, M.P.: I should like to ask Dr. Masterman a sportsman's question. We were pleased to hear of the many species of birds in the country; would he describe to us the animal called a coney. Is it a hare, a rabbit, or a rat?

Dr. MASTERMAN: The coney is an entirely separate species, rather like a large rat, with a very rough skin. It stands zoologically quite by itself, and has a different structure from any other animal. Its proper name is Hyrax. It is the animal referred to in the Bible as the coney. It has no tail; merely a stump. It is, I think, a vegetable-eating animal, and lives entirely on the herbs on the shore of the lake. It was forbidden the Jews as unclean, but I believe the Arabs eat it, and it is quite wholesome.

The PRESIDENT: There is one question I would like to ask. Dr. Masterman has referred to certain springs near the Jordan still famed for their medicinal properties. I should like to know whether in the waters of the Jordan river itself there are any healing qualities. Those large deposits of salt in the Jordan Valley remind me of the salt caves in the islands of Kishm, in the Persian Gulf, where there are great domed caverns in which the salt has taken every variety of colour, in stripes of vivid scarlet, black, lemon, or salmon. We are especially interested in the seiches of the Dead Sea water and the Lake of Tiberias, and should be obliged to Dr. Masterman if he would let us have the full benefit of all his observations on the subject. I ask you to join in a very cordial vote of thanks to Dr. Masterman for the able and interesting paper he has read.

THE DRIFT OF THE "ENDURANCE"

Lieut. J. M. Wordie, R.F.A.

Read at the Afternoon Meeting of the Society, 17 December 1917.
Map following p. 272.

INTRODUCTORY.—Definite knowledge of the Weddell Sea dates from the voyage of the *Scotia* fifteen years ago; previous to that date, though an earlier discovery, it was practically unknown at a time when the Ross Sea and the Ross Barrier at its head were well known and charted. For its north-western boundaries there were Ross's and D'Urville's charts of portions of Graham Land, and Larsen's chart of the east coast of Graham Land explored by him in 1893; in the latter voyage Larsen not only corroborated the discovery of the Seal Islands in the previous season by the *Balæna*, but also extended the known coast-line, which is here a low ice barrier, to as far south as lat. 68° 10′ S. There were also the various descriptions and charts, especially those of Bransfield, Powell, and Weddell of the South Orkneys and South Shetlands. South, east, and west, however, the outline of the continent was a blank, with the exception of the dotted coast-line which some drew on the strength of Morrell's statement that he coasted along a land trending S.E. in lat. 67° 52′ S. and long. 48° 11′ W.—about 20 miles north, that is to say, of Larsen's furthest south and more than 10° of longitude farther east.

The lateness of the season, and the long voyage still before him, unfortunately prevented Weddell from utilizing to the full the unique opportunity offered him in 1823 of pushing up to the head of his newly discovered sea. On 20 February 1823, in lat. 74° 15′ S., since the winds favoured his doing so, he decided to turn, in spite of there being open water as far south as he could see. Many have thought accordingly that the Weddell Sea was clear of pack that year; from what is now known, however, it is more than likely that close pack lay somewhere to the west of Weddell's track—that being the course which the ice slowly, but surely, takes northwards. Weddell's voyage showed that there was a deep bite into the continent; that was all.

Influenced by Ross's sounding of "4000 fathoms, no bottom," in 68° 34′ S., 12° 49′ W., Sir John Murray drew a hypothetical outline for this part of Antarctica in 1898. As events proved, however, he was too generous to the sea and too sparing with the land, for in 1904 Dr. Bruce, delayed till the end of the season, made a push south in the *Scotia* and found land in lat. 72° 18′ S. and long. 17° 59′ W., nearly eight degrees north of the position assigned it in Murray's map. Further, Bruce found bottom in 2660 fathoms within 2 miles of where Ross had recorded 4000 fathoms. So the south-eastern boundary of the Weddell Sea was fixed; and Bruce's

discovery of Coats Land must be set beside Ross's finding of Victoria Land. Fifteen years ago the land was placed 500 miles too far south; to-day as a result of Filchner's voyage in the *Deutschland* in 1912, and the more recent work of the *Endurance* in 1915, the outline of the Weddell Sea, with the exception of the south-west corner is properly charted; and thanks to Bruce, Filchner, and Shackleton, its hydrography and bathymetry are now even better known than those of the more often visited Ross Sea; while the meteorology of the Weddell Sea holds a unique position by reason of its economic application. That the *Endurance* was able to carry out so much oceanographical work is much to her credit, for she was intended primarily to land a shore party equipped for land travel at the head of the sea; and the scientific equipment was arranged in keeping with the requirements of such a party working from a fixed base.

The Ship beset.—While the *Endurance* was lying to on 18 January 1915 in a great waterpool, which had been reached with no little trouble in lat. 76° 30′ S., about 15 miles off the land, a north-easterly wind, after having blown more or less strongly for four days, rose to the strength of a gale, and packed the floes in a tight mosaic round the ship, so that on the 21st when the gale went down she was fast and helpless in the ice. For two days more the wind still blew, though lighter, from the north-east, but without in any way loosening the pack; and as it had now blown for nine days more or less strongly from that quarter, the wind must have driven all the pack-ice tight and close against the Wilhelm Barrier;* that there was an obstacle of this kind which prevented its getting away to the west and south-west is shown by the south-westerly drift not maintaining its original rate.

During the next three weeks every effort was made to extricate the ship from her difficulties; broad open water leads and lanes formed frequently, and could they have been reached they would have offered practicable ways of escape, as observation from the crow's nest showed; but in all cases the navigable leads were formed at some distance from the ship, and though she floated free more than once, it was never in anything bigger than a small pool. The most determined effort, and the final one as it turned out, was made to reach the nearest lead on February 14 and 15, but it proved a bigger task than any ship could have managed. On the next day, the young ice was as much as 6 inches thick on the lead 300 yards away, which was the objective. By the end of February, which is fairly considered a navigable month in the Antarctic, the young ice was one foot in thickness. The blame for the ship's being thus most involuntarily imprisoned must be attached, therefore, not only

* The Kaiser Wilhelm II. Barrier and Prinz Regent Luitpold Land, as named by Lieut. Filchner in 1912, are here called Wilhelm Barrier and Luitpold Coast, in accordance with a decision of the Hydrographer of the Navy made on revision of the Admiralty South Polar chart.

to the exceptionally persistent north-east winds of January, but also to the abnormally low temperatures in February.

During this time of alternate struggle to get out, and impatient waiting for more favourable opportunities, the scientific routine began to assume the form which it ultimately took on through the whole winter. Mr. Leonard Hussey was in charge of the meteorological observations, which throughout the voyage and the drift were taken every four hours. At first these were taken at four, eight, and twelve hours local mean time; this was satisfactory so long as the ship was pushing her way southward, with but little difference of longitude from day to day; but when the ship was finally frozen in and began to drift westward, it was deemed advisable that some more definite standard of time should be adhered to. Accordingly the observations from June onward were made at four, eight, and twelve hours Greenwich mean time, which for a good part of the drift was about three hours earlier than ship's time. Much of Mr. Hussey's attention was also devoted to the various self-registering instruments which were erected immediately after a winter in the pack was seen to be inevitable; among them he was able to include a Dines anemometer, this being the first time that such an instrument has been successfully set up in the Antarctic. Great credit is due to him for being able to keep this instrument going right through the winter, even during the strongest blizzards, and for overcoming the troubles caused by drifting snow and growing rime. During the early months of the drift rime was quite the worst bugbear; Mr. Hussey finally overcame it: and I think the same can be said of Mr. R. W. James, the physicist. The latter at regular intervals determined the various magnetic constants, partly in the open, partly in a snow-hut which was built for him; and along with Lt.-Commander Worsley, R.N.R., Sailing Master, made almost daily determinations of the ship's position. It was soon noticed that the sextant without an artificial horizon was not a reliable instrument for determining the ship's position when in the pack. The rough hummocky nature of the latter does not give a level horizon, while even when the horizon is clear and level it is constantly liable to abnormal refraction due to intervening stretches of water and other causes; from May onwards, therefore, throughout the winter, a 3-inch theodolite was often in use as well, and were it not for the trouble of using it in cold weather it alone would have been used. Positions with the theodolite could always be relied on as accurate to within 1′. Later on, however, when the ship was abandoned, the sextant came into more frequent use again. An interesting feature of this work was a series of occultation observations for rating and correcting the ship's chronometers. The first of these were taken in June 1915, exactly eight months after the ship's departure from Buenos Aires; and the result of four occultations taken that month was to show that the ship was over 1° farther west than had been deduced with rates determined at that port. Later, when more occultations came to be observed in July, it was possible

to fix new rates for the chronometers, and the August and September observations accordingly never involved more than slight changes.* After the ship was crushed in October 1915, and the box chronometers had to be abandoned, owing to the space they required and the utter impossibility of keeping them at a constant temperature, recourse was had to four chronometer-watches, which had been rated daily for nearly a year. Six months later, when land was sighted in March 1916, and bearings to Joinville Island could be taken, Mr. James and Mr. Worsley found that their calculated position was only 10′ too far to the east. Mr. James also undertook various determinations of the salinity of sea-ice; and after much trouble, which all must experience who have to deal with instruments under abnormally low temperatures and with obstructions by rime, succeeded in getting daily charts of the atmospheric electric potential gradient.

Probably the busiest man on board was the biologist. For four months during the drift the depth only once exceeded 600 fathoms, and accordingly his dredge was down more often than not, the deepest haul being in 419 fathoms. Besides the abundant material which he got from the dredge, Mr. Clark made almost daily collections of plankton from the surface and at various depths. It is much to be regretted that such a rich collection of biological material, whose preservation entailed so much patience and care, should have had to be abandoned owing to its bulk when the *Endurance* was crushed by the ice. Mr. Clark and myself co-operated in the oceanographical work, spending much time in sounding, collecting water samples, and making temperature observations at different depths. This, with work on the sea-ice, was my own particular sphere.

The Pack Ice.—When first beset the *Endurance* was jammed amongst old hummocky floes, formed in a previous winter probably somewhere to the east of Coats Land, and cemented by loose brash and rubble. After some weeks the latter, owing to the cold weather which prevailed in February 1915, settled down into something more solid, which ultimately under a snow covering took on all the appearance of an old hummocky floe. It became a duty, therefore, to study the successive changes which sea-ice undergoes from day to day, in other words to study its natural history. Numerous observers have described how sea-ice is built up of small plate-like crystals, which in the upper half-inch or so of ice arrange themselves parallel to the surface, but lower begin to assume a perpendicular position grouped somewhat in bundles, and so on downwards: fresh plates attaching themselves perpendicularly to the ice already formed, so that in section a block of new ice shows vertical striæ, as it were. This was as far as the polar geologist ever went; but there is no little difference

* These occultations have been recalculated with the observed places of the Moon, by Dr. A. C. D. Crommelin of the Royal Observatory, Greenwich, through the courtesy of the Astronomer Royal. The largest change made by this correction to the Moon's tabular place is one of 10′ of long. in lat. 73° 15′ S., equivalent to about 3 miles.

between moderately salt ice showing these vertical striæ and the comparatively fresh ice of spotted texture from hummocks and pressure ridges which has been used immemorially to water ship in the polar regions. To explain this difference was one of the pleasantest tasks I had, involving almost daily scouring over the pack during the fifteen months' drift. In this period there were many opportunities of seeing the changes which the ice undergoes in structure, salinity, and specific gravity—for one of the first things noted was that the specific gravities of ice showing vertical striæ clustered round 0·92, whilst those of comparatively fresh spotted ice were nearer 0·91.

The structural change was found to follow a history somewhat as follows: Provided the floe was not disturbed throughout the winter, fresh ice went on forming, but at an ever slower rate; all ice so formed shows vertical striæ. Then two things may happen: either this sheet of winter ice is broken up to form a pressure ridge, or else it remains undisturbed throughout the summer. In both cases the high summer temperatures will have their effect: in the former case, where there has been pressure, to so alter the ice that it becomes sufficiently fresh for drinking purposes; in the latter to bring it up to nearly melting-point and at the same time to disintegrate it slightly, so that on re-freezing it takes on a granular or spotted structure, but still retains some of its salt, unless it should have been raised into a pressure ridge or hummock in the interval. For ice to entirely lose its salt, not only are a summer's high temperatures necessary, but also that the ice in question should be raised above sea-level. Should the first only of these factors come into play, the ice will become spotted and distinctly fresher; should the second also occur it will become sufficiently fresh for drinking purposes, and will also assume the spotted structure, sometimes with an arrangement of the spots in lines marking the original striæ. At a glance, therefore, it is possible to tell whether ice from a hummock is fresh or not, simply by its structure; there is a certain clearness about it which salt ice lacks.

From time to time Mr. James and myself undertook determinations of the chlorine in the different ice layers, the method being to put down shafts from time to time in level undisturbed ice which was still afloat, and to determine the amount of chlorine present by tritration with silver nitrate. In sea-water the proportion of chlorine to the other salts is nearly constant; but in the small proportion of salt which gets caught up mechanically during the freezing of sea-ice, it is very unlikely that the same ratio holds; results must be given therefore in terms of the chlorine present and not of the total salt. The outcome is that the ice which began forming in February 1915 was still slowly losing chlorine between 7 September and 13 October 1915. This was the kind of ice described above as having fine vertical striæ characteristic of ice crystallized from sea-water, the striæ being merely the edges of vertically arranged plates. These results, from samples of ice every 20 cms. downwards show that

the amount of chlorine has no relation to the depth; it more probably depends on the rate at which the ice was forming. On the other hand it is clear that the salt slowly drains away from ice still below water-level. A third vertical series of samples of spotted ice, formed mainly in a previous winter (1914), but the lower layers in 1915, show a much lower proportion of chlorine than the others, due to the longer period in which the salt could drain away; but the newer bottom layers have not had this advantage, and have still some chlorine, though not very much, as this particular floe had a 2-feet-thick covering of snow, which must have made crystallization a very slow process. Spotted ice contained less than 0·2 per cent. chlorine, therefore, in this series, with the exception of the surface layer, which contained an extremely high proportion; but this was undoubtedly due to the weight of the snow covering having depressed the upper surface of the ice below water-level and thus allowed the seepage of sea-water horizontally between snow and ice. It in no way affects our conclusions that sea-ice becomes fresher while still in its position of growth, and when pressed up into hummocks becomes almost entirely fresh. It was very much to be regretted that all this work was put a stop to when the ship was crushed, while there was still so much else that we wanted to know; so far as we can find, no one else has followed up the work on sea-ice first started by Mr. J. Y. Buchanan.

Measurements were continuously made to determine the rate at which undisturbed sea-ice will grow, and to get some approximate idea of the average thickness to be expected from icefloes in the Weddell Sea. Fortunately more than one floe of newly formed ice was examined, for by the end of the winter the continual cracking, rearrangement, and rafting of the ice had destroyed all these places where observations were being made excepting one. At this spot a measurement made on 13 October 1915 showed a thickness of 145 cms. formed since February 6, *i.e.* 57 inches in a little over eight months. As there was nothing to prevent the ice there still growing for at least another month, one can safely say that a winter's ice in these parts of the Weddell Sea amounts to about 5 feet in thickness. In still more southern latitudes still thicker ice can be expected, more particularly if the snow covering by reason of blizzards should remain thin as well. In an old pressure ridge, for instance, at some distance from the ship there was a block of ice 7½ feet thick, which showed by the presence of diatoms only in its lowest part that it must have been formed in a single previous winter, presumably in 1914, and therefore in a much higher latitude. As far as observations went, it appeared that it is only in the summer and autumn months that diatoms frequent depths in the water where they are liable to be frozen into the growing sea-ice, and more particularly in the autumn; if due attention, therefore, is paid also to the texture of the ice above and below these diatom bands, they form a useful guide in fixing the minimum age of a particular floe. When in

April 1916 the pack ice finally broke up, one could positively affirm that some of the ice was at least two years old, but in no case could it be proved to have begun forming in 1913, although floes as old as this (three years) may not be impossible in the Weddell Sea.

The mobility and constant regrouping of the ice-floes constituting the Arctic pack is familiar to all readers of Nansen's 'Farthest North,' where he describes the slow progress of the *Fram* across the Polar Basin. The *Endurance* progressed in much the same way round the Weddell Sea, but at a faster rate, due possibly to stronger winds. For her drift was primarily caused by the wind; that there is a current as well is most likely, but its nature and extent will only be determined when the force and direction of the winds can be compared with the ship's daily change of position. At present there are the data to do this, but not the time to spend on it.

Just where and why cracks should form in the ice is a problem which has still to be solved. At its first forming the sea-ice is presumably floating in equilibrium on the water, every part being properly supported; but as time goes on this can no longer remain the case, owing to the uneven accumulation of drift-snow on its surface, and the unequal rate of freezing which must result. Certain parts being now in a state of tension, cracks are to be expected there any time. But some start has to be given, and this is apparently done by winds of blizzard violence. It seemed to me that cracks formed either during a blizzard or when there was a dead calm: light winds did not appear to have this effect. The proof of tension lies in the fact that a crack as soon as formed has an appreciable width, which may not be altered for some days; and also in the fact that the sides of a newly formed crack frequently float at different levels. Whether these cracks widened into leads or not, they always remained lines of weakness: later cracks were always liable to become diverted by them, and accordingly, supposing that there was a plan governing crack-formation, it was almost impossible to discover it. These observations apply to the close pack in which the *Endurance* drifted far from the open water. At the end of the second summer (in March 1916), however, when the ice was looser and the position of the camp not far from the pack-edge, there was no doubt that the cracking of the floe was due to the disturbance of its equilibrium by swells coming in from the open sea, and in this case the cracks apparently ran parallel to the crest of the swell. This was so in the case of a crack which formed in the early morning on March 30, and was followed a few hours later by a second parallel to it.

If a crack is going to open out into a lead, it is more likely to do so when there is a very strong wind or when it is calm than during light winds. For even under such tight conditions as the head of the Weddell Sea in winter the pack in its northerly course is always opening out and covering a wide area. A lead may go on opening for days, whilst the first formed parts are already covered with fresh ice. But inasmuch as the floes do not

travel at the same rate, a lead is always liable in the end to close up to some extent. In close pack-ice a crack or lead therefore will always be the possible site of a pressure ridge. Sometimes only the thin newly formed ice will be pressed up by a process known as rafting; but occasionally the older thick floes also are involved and built up into heavy pressure ridges, which may be as much as 15 to 20 feet high. On one occasion a pressure hummock was found about 30 feet in height, but it was distinctly exceptional: a 15 feet high pressure ridge is quite entitled to be called high, and will certainly cause anxious moments to those on board a ship which happens to be involved in it. Very rarely does a lead close evenly, so that the two sides fit once more into one another; usually one floe shears past the other, and projecting corners are the first to get broken up: probably the shearing process helps on the piling up of the ice-blocks into hummocks and ridges. If the pressure formation is very heavy and intense it gives the impression of eating up the floe in its advance: the weight of the already formed ridge weighs down the floe in front, till ultimately a crack develops parallel to and slightly in front of the advancing pressure; associated with such a "hinge crack" there are generally formed a few smaller radiating cracks, thus dividing up the ice into blocks, which then get caught up in the advancing ridge. Possibly a "shock crack" may also form, but at right angles to the pressure and simply due to the shock of concussion of one floe against the other. Such a process as this which I have described only accompanies intense pressure. Usually small ridges are built up by shearing and rafting to a height of 5 to 10 feet, whilst smaller inequalities get snowed over and softened down. At the close of the winter the ice right to the horizon was cut up and divided by pressure ridges such as these; from the crow's nest or a high berg one seemed to look down on to a land of fields and hedges, more haphazard than the most irregular English landscape, but resembling it sufficiently to give point to Sherard Osborn's remark on "the hedgerows of Arctic landscape."

The Continental Shelf.—The deep-sea sounding equipment on board consisted of a Kelvin sounding machine with dial graduated to 300 fathoms, a Lucas sounding machine for depths to 1000 fathoms, and a still larger Lucas machine capable of sounding to about 5000 fathoms. The two latter machines were fitted with piano wire; the Kelvin machine with a three-stranded wire, to which instruments could be safely attached. From the date on which the ship left South Georgia till she was beset in 76° 30′ S. twelve casts were made, most of them off Coats Land, and particularly that part of it named Caird Coast.* As a rule these soundings

* As a name seemed desirable for the whole body of land on the eastern side of the Weddell Sea, Coats Land has been extended from its original limits between lat. 72° S. and lat. 74° S. to act as a more general name. Caird Coast and Luitpold Coast are therefore to be regarded as parts of Coats Land, in the same way as Trinity Coast and Foyn Coast are parts of Graham Land.

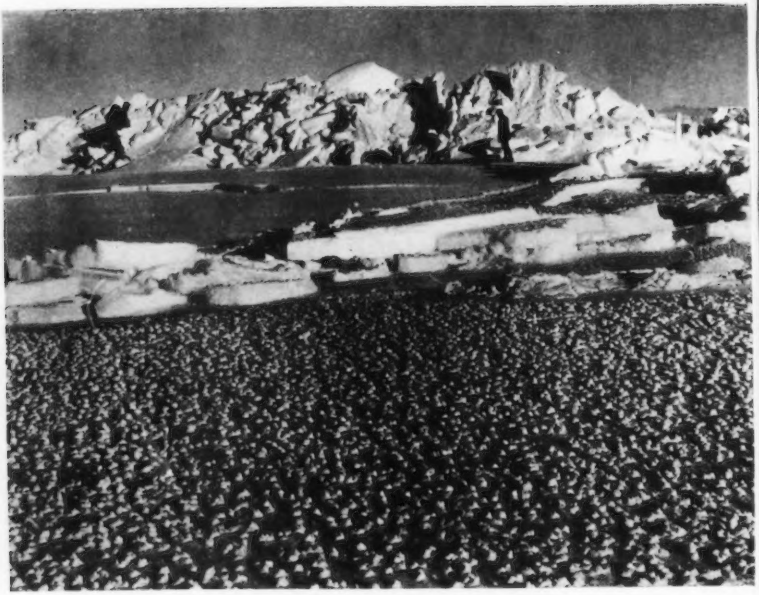
along the coast, which was mostly barrier-ice with occasional glacier faces, showed depths of between 100 and 200 fathoms; but there was an exception off the rather remarkable protuberance of barrier in lat. 74° S. A cast close under the barrier cliff, which was here 80 feet high, gave 676 fathoms, no bottom; whilst a cast 10 miles off, in lat. 74° 10′ S., long. 27° 21′ W., gave 1355 fathoms. These compare with Dr. Bruce's sounding of 1155 fathoms when 15 to 20 miles from the most northerly known point of Coats Land, and show that the continental shelf in this part of the Antarctic is not so very broad. In the first two months after being beset, sixteen soundings were made along an east-to-west line between lat. 76° 40′ S. and lat. 77° S., the deepest of this series being 606 fathoms in 70° 53′ S., 37° 17′ W. From a comparison of these soundings with those made by the *Deutschland* about a degree farther south, it is probable that there is here a line of deep water running south to the Wilhelm Barrier, and that eastward the bottom gradually shallows to less than 100 fathoms off the Luitpold Coast, while to the west there is a somewhat steeper rise to depths of 250 fathoms or less, marking the edge of what has generally been spoken of as the continental shelf.

The ship drifted on to the continental shelf in the last week of March. From the 31st of that month, when the depth was 256 fathoms, till July 31, when the depth was 185 fathoms, no sounding exceeded 275 fathoms: some were no more than 150 odd fathoms, while the majority were round about 180–190 and 250–260. During this four-month period soundings were taken every day with but one or two exceptions; their total is over 100, and they are the means of showing very accurately the details of the form and the possible extent of the submarine shelf in this part. It was investigated over a length from south-east to north-west of at least 270 miles, and owing to the backward and forward way in which the ship drifted, the breadth in the south-east is known to be about 40 miles, and in the north-west 70 miles. These figures give the breadth of the continental shelf as known and sounded by the *Endurance*; but it is probably very much broader, for when the under-water contours are drawn (and they can be accurately drawn in without hesitation), they are found to run S.W. to N.E., that is, at right angles to the mean line of the course, and at right angles also to the presumed coast-line bounding the Weddell Sea on the south-west. If these contours are continued but a little distance, the platform will be over 100 miles broad.

No gradual shallowing can be traced in any direction, and therefore no hints can be gathered in this way as to how far off the coast is. The shelf, as surveyed two years ago, is made up of a group of terrace-like levels, whose edges are steep and are nearly parallel to each other along a S.W.–N.E. line. In the south-east there is, first of all, a small gently sloping platform about 250 fathoms deep; then a much larger almost level area averaging 180 fathoms. This is bounded on the north-west by a small platform of 150–160 fathoms; then follows a very

THE SHIP WORKING THROUGH A LEAD

THE "ENDURANCE" BESET IN MARCH 1915



PRESSURE RIDGES, APRIL 1915

MR. HUSSEY AND DOG-TEAM, SEPT. 1915

large area practically level with depths from 250–260 fathoms, and this again is bounded on the north-west by a still broader and larger platform of 180–190 fathoms depth. Then there is a fairly rapid fall, along the course which the *Endurance* took, to 1146, 1550, 1676, and finally 1900 fathoms.

There seems to be no very satisfactory explanation to offer for the details of this curious form of the continental shelf, if it can be called by that name, for its average depth is twice that of the shelf which fringes countries outside the South Polar regions. Some other explanation must certainly be found than that of Philippi, who thinks the greater depth of the shelf in the Antarctic is due to planing down by ice during the once greater extent of the Antarctic ice-cap. The terraced nature of the shelf, which the *Endurance* soundings indicate, disproves Philippi's idea, and makes it very doubtful if it can any longer be spoken of by the name of continental shelf.

Morrell's land.—The last shallow cast was in 185 fathoms in lat. 73° 37′ S., long. 47° 53′ W. on 31 July 1915. For the next three days a strong blizzard blew from south-south-west, which broke up the ice round the *Endurance* and produced such heavy pressure as to endanger the ship. Up to this date she had lain very snugly in the berth cut for her in February, but one of the first effects of the blizzard was to intensify in the floe south-west and directly under the ship's bows an eating-up process which had been going on during the last weeks of July. On August 1 a crack formed athwartships, opening very rapidly, so that finally the ship broke out of her berth and floated freely again; but as the blizzard continued, and the movement of the floes became more intense, she was once more nipped, raised by ice driving under her, and tilted to port. The result of the pressure was to damage the rudder slightly, and at the same time to demonstrate the ice-worthiness of the ship. It was not till August 4 that another sounding could be made—450 fathoms, no bottom. After a long disuse, the Lucas machine had again to be put in working order; and a sounding the next day gave a depth of 1146 fathoms in 71° 42′ S., 49° 21′ W. There is therefore a gap of nearly 60 miles between the shallow and the deep soundings, making it doubtful where exactly to place the edge of the shelf. The pair of soundings, however, compare with 279 and 1476 fathoms by the *Belgica* 25 miles apart; 209 and 1267, 18 miles apart, taken by the *Gauss*; and 159 and 1950, 45 miles apart, taken by the *Scotia*, and make it likely that here also the edge of the continental shelf is a steep one, and should therefore be placed nearer the deeper of the two soundings.

Once off the shelf, soundings were made only about every ten days, according as the ship had drifted in the interval; up to the time when she had to be abandoned, seven casts were made in depths exceeding 1000 fathoms, the deepest of these being 1900 fathoms in 70° 9′ S., 50° 13′ W. As the series of *Deutschland* soundings, made in 1912 90 to 150 miles

farther east, always show a deeper sounding in each corresponding latitude, it is possible to draw contours, which are found to run at first south-east to north-west, and then north to south up to lat. 65° S., where they begin to run to the north-east and east. When this is done, one finds not only the 1500-fathoms line, but also probably the 2000-fathoms line, passing to the west of the position assigned by Morrell to his record of land in 1823.*

The drift of the *Endurance* actually took her to the west of Morrell's position, and most effectively showed that Morrell's land—if it exists—is certainly no part of the Antarctic continent. Morrell fixed only one position astronomically along the land so called—on March 17 when he found he was in 67° 52′ S., 48° 11′ W. The nearest the *Endurance* drift ever came to this point was about 75 miles, whilst the *Deutschland* was never nearer than 90 miles; there is room, then, for an island of some size, or for "a cluster of islands," to use the term which Sir James Clark Ross's officers entered in the log of the *Erebus*, when describing what their commander has charted as "strong appearance of land" on much the same meridian as Morrell's land, but nearly 3° of latitude farther north.

It was at one time the fashion to discredit Morrell's account of his voyage, which, in so far as it relates to the Weddell Sea, is unfortunately very brief, only four pages in a narrative running to nearly five hundred; but these four pages are quite moderate in tone, and fairly definite in all that refers to his discoveries. Occasionally the narrative is coloured and ornate, but this style was not out of keeping with the date at which it was written. Further, if Morrell were writing a fictitious narrative, I think it more than likely that he would have claimed the discovery of land for himself rather than have attributed it to his old master, Captain Johnson; he regards it merely as a part of New South Greenland—a name which like New South Iceland was used rather loosely by the American sealers of that time, for what is now called Graham Land and the South Shetlands. One is, I believe, justified therefore in regarding Morrell's voyage into the Weddell Sea in 1823 as fact. That he encountered practically no ice is not surprising, as for part of the voyage he was covering ground which had been sailed over for the first time in history only three weeks previously by Captain James Weddell. Morrell believed he was a year later than Weddell, and says so in his narrative, but the fault is Weddell's for overlooking a misprint of 1822, which should have been 1823, in his account of his voyage. They both had the good luck to go south in the one year in which we know that there was practically no ice in the Weddell Sea—the enviable year to all later explorers.

Morrell states that he had some trouble with field ice on March 10 and 11 in 64° 21′ S., 38° 51′ W. Having got through, he proceeded to

* In preparing the map which accompanies this paper and illustrates the problems of Morrell's land, advantage was taken of the excellent collection of Antarctic literature and charts at the Scottish Oceanographical Laboratory, which were very generously placed at my disposal by Dr. Bruce.

steer south under double-reefed sails till the 14th of the month, when he was in 70° 14′ S., 40° 3′ W. The air temperature was 47° F., and the water temperature 44° F., the variation 14° 27′ easterly. At this point Morrell found it necessary to turn, having, as he says, no fuel and not twenty days' water; but he seems to have much regretted not being able to push farther into the then clear, unobstructed sea, and says: "To the only free nation on earth should belong the glory of exploring a spot of the globe which is the *ne plus ultra* of latitude, where all the degrees of longitude are merged in a single point, and where the sun appears to revolve in a horizontal circle. But this splendid hope has since been lost in the gloom of disappointment! The vassals of some petty despot may some day place this precious jewel of discovery in the diadem of their royal master. Would to Heaven it might be set among the stars of our national banner!" Had Morrell been an impostor, surely he would have claimed a higher latitude than Weddell's; and yet he turned back 4° further north. He then stood to the north and west till on Saturday, March 15 at 2 p.m., land was seen from the mast-head bearing west distant 3 leagues. "At half-past four we were close in with the eastern coast of the body of land to which Captain Johnson had given the name of New South Greenland." The coast ran about south-by-east. That afternoon and evening the boats were out hunting for seals, the vessel following or keeping abreast of them, about 2 miles from the land until 4 p.m. on the 17th, when the position was 67° 52′ S., 48° 11′ W. This was the third position fixed in the Weddell Sea, and the only one for the land along which he had now been coasting for forty-eight hours. Variation per azimuth at 9.0 a.m. 16° 4′ easterly. The coast here tended about S.E. by S., and Morrell thought he could discern mountains of snow about 75 miles southward. Shortage of fuel and water prevented exploration of the land farther south, so he therefore turned and went north, and under date March 19 says: "Close in with the north cape of New South Greenland; lat. 62° 41′ S., long. 47° 21′ W. by dead reckoning, not having had an observation for three days; coast tending to the south, and S. by W."

Later voyages have definitely shown that there is certainly no land in this last position; but in the same latitude and 8° of longitude further west there lies Joinville Island, the *real* north-east cape of what was then known as "New South Greenland" or "New South Iceland." Now Morrell is very definite as to land here; and therefore I conclude that his chronometers must have been so far out as to make an error of at least 8° of longitude, or possibly 10°, seeing that the last position is one obtained by dead reckoning. If this correction is applied to the position in 67° 52′ S., Morrell's land comes almost to coincide with the east coast of Graham Land. Knowledge of this part of Graham Land is based solely on Larsen's journal of his voyage in December 1893, and there is a probability that his longitudes are slightly farther west than he made them; this at any rate was the case with his fixing of the position of the

Seal Islands farther north, which Dr. Nordenskjold in 1902 had to place farther west on the map. Now whether Foyn Coast, as Larsen called it, is in 60° W. or in 62° W., is of little matter, seeing that Morrell's longitudes were presumably nearly 10° out: the main thing is that the land which Larsen sailed along in 1893 is not unlike the idea which Morrell gives the reader of his land in 1823. Larsen found seals on the pack-ice below a low ice-barrier, just where, I take it, Morrell says he had his boats out sealing along the coast.

Once land gets laid down on a map or chart, it is always a very difficult thing to remove it; but Morrell's land has never even had a firm foothold on our maps, so there must be very few who will object to its now being omitted altogether, in view of the inferred large chronometer error, and now that the likelihood of its being a part of Graham Land has been shown. Sir James Ross's "strong appearance of land," however, is still left, and that will have to stand till further exploration is made there; it is worth noting, however, that the pack-ice during the end of 1915 and the beginning of 1916 was never impeded when driven towards this spot in any way more than it would have been had there been open sea there. The same argument can be applied just as strongly to the position formerly assigned to Morrell's land: the floes on which the crew of the *Endurance* were drifting were not held up when compelled to travel in that direction. When the winds come to be worked out, I think the evidence on this point will be almost conclusive.

Comparison of the Drift with that of the "Deutschland."—On studying the course of the *Endurance* drift and comparing it with that of the *Deutschland* a well-marked "kink" will be noticed in both of them, marking where a mean north-westerly course became almost a northerly one in both cases. In the case of the *Deutschland* this was in 72° 20′ S.; in the case of the *Endurance* about 160 miles south-west of the above in 74° 10′ S. It seems not unfair to infer from this that the unknown coast still farther to the south-west shows a somewhat similar sharp change in its direction. This same alteration in the mean course of the *Endurance* drift must also rule out the possibility of there being a strait other than one filled by barrier ice to the south of Graham Land, making it an island. I feel sure that if there had been any such passage, the close pack, always drifting as far to the west as possible, could hardly have done other than be driven through it. To draw any further conclusions about the unseen coast to the west of the Weddell Sea would not, I think, be justified.

The drifts of the two ships in the high latitudes are remarkably similar, although the *Deutschland* was three months ahead in the first part of her course, and at least four months ahead in the latter part. But if there are similarities, there are also some pronounced differences. One is the different rate at which the ships drifted; the *Deutschland* averaged six sea miles per day; the *Endurance* only four, computed from a course which is the sum of the distances between one observed position and the next.

One concludes that the ice moves more rapidly the farther it is from land, nearness to the open sea meaning a looser, more mobile pack. It was due to the ice towards the coast moving so slowly and being perhaps in places almost stagnant, that the floe on which the crew drifted in the summer of 1915–1916 after the *Endurance* had been abandoned, gradually came closer to Graham Land. In 67° S. it was 160 miles from land, in 65° S. 90, and in 63° S. only 40 miles. The pack, therefore, away from the coast was shearing past the inshore ice. This closer and closer approach to the land was, however, a feature which the *Deutschland* did not experience. The German ship was steadily taken north-east and almost east, once north of 60° S., and it looks as if she had come under the influence of the westerly winds, and that, if she had not had steam to take her the 300 odd miles to the pack edge, she might even have got involved in what Mr. Mossman calls the "Weddell Sea Doldrums"; but the *Endurance* crew, farther to the west, was still subject to the 'long shore winds, and only met the westerlies after gaining the latitude of Joinville Island.

Break-up of the Pack.—On 9 March 1916 a faint swell was noticed for the first time in the ice, and was the first sure sign that the pack was nearing its end, for swells from the open sea do more than anything else to break up heavy pack-ice. Once it begins heaving up and down a big floe will soon crack, and the pieces so left will have a much longer axis parallel to the crest of the swell; but the swell at the same time is loosening the pack and making the floes swing more easily, so that the long axes soon get turned round end on to the swell; then another crack will form and reduce the floe to a nearly equi-dimensional area once more, and so on, the influence of the swell being to break up the ice into smaller and smaller floes. By the beginning of April the number of cracks in a formerly big floe had made the pack-ice about the least comfortable of homes. But still it refused to open sufficiently for boat work, till the latitude of Joinville Island was passed. There the currents of Bransfield Strait drive the ice eastwards, and break off and whirl away fresh areas as they come round the corner of the land. The ice had almost reached the middle of Bransfield Strait when at last it was found possible, on April 9, to launch the three boats; on that and the two previous days there had been heavy swells. For three days the boats following a devious course tried to work first north-west in thick weather, and then, owing to the presumed westerly position, south-west as was thought towards King George Island, only to find, when it cleared and a position could be observed on the 12th, that they were somewhat south-east of where they had been launched. Where there was close pack ten days previously there was now open water and a few scattered floes. The winds for three days had been easterly, and the course, though slow, westerly; so this observed position is proof of the strong eastward travelling current in this part of Bransfield Strait. The boats, substantially

aided by a south-east wind on the 13th, were now able to take a straight course for Elephant Island, while the ice which had formerly hindered them, driven east by the current, was now being lashed and tossed by the waves on its way to the South Orkneys, to finally end its history as "growlers" and "bergy bits" in the South Atlantic.

Before the paper the Chairman (Dr. H. R. Mill) said: We were all disappointed that Sir Ernest Shackleton was not able during his brief stay in this country to give us an account of the great expedition that he carried out on board the *Endurance*, but we are fortunate in having one of his staff, Lieut. Wordie, with us. He was in charge of the oceanographical work of the expedition, and will, with the permission of Sir Ernest Shackleton, describe the results obtained during the drift of the vessel. You remember that Sir Ernest Shackleton started in 1914 with the intention of crossing the Antarctic continent from a base on the Weddell Sea, south of South America, and returning from his old quarters on the Ross Sea. Two ships were sent south, the *Aurora* to the Ross Sea to await his arrival; the *Endurance*, in which he sailed, to the base on the Weddell Sea. Unfortunately, a summer of unprecedented severity made it impossible to reach the land, and the ship was caught in the ice and drifted northward in a manner which prevented any possibility of carrying out the expedition as originally intended. But during this drift extremely valuable observations were made, and the opportunity so unfortunately presented was taken advantage of to the very uttermost. In the course of his paper Lieut. Wordie will have occasion to mention the names of other explorers, and I think it will simplify matters if I repeat the names in chronological order of the very few adventurers who were in this sea before the *Endurance*. Captain James Cook on his second voyage in 1772 crossed the region between South America and the meridian of Greenwich, without making any high southern latitude. In 1820 his successor, the Russian Captain Bellingshausen, who was sent out with express orders to go south where Cook kept north and north where Cook went south, did his best to penetrate into the sea, starting from the meridian of 40° W., which is practically that of the south point of South America. He succeeded in almost reaching the 70th parallel on the meridian of Greenwich, but could not get further south on account of the ice. In the same year Bransfield in the *Williams*, the ship of William Smith who had discovered the South Shetlands the previous year, got south to 64° near the meridian of 40°. In 1823 there were also two vessels in this sea; one made a very remarkable voyage, the other had a somewhat wonderful tale to tell. One of these ships carried Weddell, who succeeded in getting to a little more than 74° S., finding the sea open, about the 60th meridian, and he returned on account of the want of food, water, and wood; therefore he thought he could have got to the Pole, or at least 85° S., if he could have kept on. In the same summer the American whaler Morrell described a voyage on which he reached the coast of New South Greenland and followed it to its north cape in latitude 62°. Dumont D'Urville of the French Expedition was sent out in 1838 with orders to follow the track of Weddell and gain a higher latitude if possible. But he was not able to get through the ice, and did not even reach the Antarctic Circle. He did not carry his efforts very far to the east, as he was extremely anxious to return to the Pacific Islands to carry out anthropological work. The next visit was that of Captain James Clark Ross in 1843, who, after a very arduous battle with the ice, succeeded in making a passage through the pack midway between the points where Weddell and Bellingshausen penetrated. He got south to a little over 70° and made a

remarkable sounding of which we shall hear. After that date there was half a century in which the Weddell Sea was left entirely unvisited. Then in 1892 this Society fitted out certain Dundee whalers and succeeded in inducing them to take as Surgeon-Naturalists Dr. W. S. Bruce and others. In the Antarctic autumn of 1893 these ships went out along the east coast of what we may for convenience call Graham Land, although it was originally intended that that name should apply only to a small area on the west coast. Simultaneously and immediately afterwards Norwegian whalers and sailors went out, and one succeeded in getting south to about 69° along that coast. In 1903 Dr. Bruce, in command of the Scottish expedition on board the *Scotia*, made two most remarkable and successful voyages through the centre part of the Weddell Sea, discovering Coats Land at its southern border; and Dr. Otto Nordenskjöld also made an expedition along the coast in the west. After that came the expedition of Filchner in the *Deutschland* in 1912. He intended to land, but did not succeed, though he extended the coast a little before he was caught in the ice and drifted out. Then came the expedition of the *Endurance*, which produced the paper by Lieut. Wordie.

(*Lieut. J. M. Wordie then read the paper printed above, and a discussion followed.*)

The CHAIRMAN: We have listened with great delight to this exposition of the work of the *Endurance*, and I think we must congratulate Lieut. Wordie on his generous treatment of his predecessors. It is a refreshing and not altogether a universal attitude of explorers when they come home. His generosity even extends to our old friend Morrell, who has supplied the humour of Antarctic exploration for nearly a hundred years. I am particularly gratified at the conclusion Lieut. Wordie comes to with regard to Morrell, for it is identical with the opinion which I formed when writing the 'Siege of the South Pole' twelve years ago. I regret the absence of Dr. W. S. Bruce, who had hoped to be present and to give us the benefit of his unique experience; but several Antarctic explorers are here to express their views.

Captain Sir DOUGLAS MAWSON: I take this opportunity to congratulate not only Mr. Wordie himself, but their leader and all his gallant companions, upon their endurance, perseverance, and ability in difficult and dangerous circumstances; the combination of which qualities coupled with good fortune was necessary to effect their safe return after such amazing adventures on the southern pack-ice. It is a great pleasure to learn how many scientific observations they found it possible to make notwithstanding the difficulties of the prospect. The altered circumstances of a campaign upon the sea, instead of upon land, as was originally intended, has resulted in the accumulation of equally valuable information relating to the natural history of the pack-ice and the oceanography of the Weddell Sea.

As to Morrell's story of land in the Weddell Sea—the New South Greenland of some charts—I think that Mr. Wordie has been exceedingly generous, and indeed gone to unnecessary trouble in explaining away the evidence for that land (now apparently proved not to exist) as an error of Morrell's chronometers. The explanation advanced is quite sound, and one would say nothing more about it were it not that exaggerations and impossibilities figure altogether too freely in Morrell's account of his voyage. The book is no doubt founded on a substance of truth, and upon a lifelong experience at sea under the hard conditions of those times. In reading it I gathered that it was written in the reflective light of later years; those distant days of daring no

doubt loomed large, and the events were miraged out of proportion and given a piquancy so common in sailor's yarns. It was more important to illustrate what a variety of daring adventures the author was hero of, than to furnish an accurate account of lands and places visited. The whole reads splendidly as a book of adventure, and, as it is all founded on personal experience, it is valuable as giving an insight into the life of the mariners of those days. But it appears to me that a few degrees of latitude or longitude were neither here nor there, and this is further suggested by the absence in the book of any sort of map. If his longitudes are out in the case of New South Greenland, his latitudes and runs in the earlier part of the same voyage, after leaving Kerguelen Island, must also be explained away. Dr. H. R. Mill and others have long ago drawn attention to these inaccuracies; and I am now only stating my own opinion after reading his narrative. Morrell, in my opinion, proves himself no serious geographer, not only in his loose handling of such exact matters as time and place, but also in his descriptions of many of the natural phenomena recorded.

After what Mr. Wordie has told us there can exist only small islands, if any land at all, between the drift of the *Deutschland* and the drift of Sir Ernest Shackleton's party. Ross's "indication of land" there is in my opinion outbalanced by the absence of any indication either in the depth of the sea or in the drift of the pack-ice as observed by the two expeditions. An indication of land in that direction, suggested by the meteorological observations of the Scottish Antarctic Expedition at their South Orkney station, appears to me to be explained by the now proved continuation, during a part of the year at least, of an ice sheet over the sea from the Antarctic in the south to the South Orkney Islands themselves. The effect would be to mask in very great degree the influence of the sea, and to carry the continental climatic conditions to the South Orkneys station.

As amplifying what Mr. Wordie has said on the subject of sea-ice and its salinity, I would like to say a few words in the light of serial salinity observations made with Buchanan's hydrometer on Sir Ernest Shackleton's previous expedition, and on the Australasian Antarctic Expedition. One cannot emphasize too strongly that ice is rock in a geological sense, and is to be treated petrologically as such. It is a rock in which there is a vast excess of one substance above the composition of the eutectic mixture of all the ingredients. Water of absolute purity yielding ice of absolute purity is practically unknown in Nature. In the refrigeration of sea-water, if complete, the eutectic bulks large; but this condition is never attained in the formation of floe ice. As freezing proceeds downwards, the temperature is such that only pure ice tends to form (porphyrite), the saline cryohydrates of lower freezing-point (the eutectic ground-mass) sinking down into the body of the sea-water below, *pari passu* with the separation of plates of pure ice above. But the condition of a pure-ice floe is never attained, for brine is invariably retained accidentally, caught up in the interstices of the ice plates. The amount of saline matter retained is roughly proportional to the rate of freezing, and is therefore initially less in the deeper layers of the floe. In course of time, even during the winter under low temperature conditions, some of this interstitial saline liquid is driven out either above or below. That exuded above becomes absorbed by the first layer of snow to fall upon the ice surface. In any case during the winter the elimination of brine is very irregular, and never more than partial. In summer under warmer temperature conditions a larger bulk of correspondingly more diluted brine is thawed in the interstices, and the ice becomes more

porous. In mid-summer it may even reach the porosity of a sandstone. Though the mass of ice remains unaffected, preserving the solidity of the floe, the sun's heat is sufficient to melt the interstitial brine on a generous scale and this is gradually displaced downwards by the fresher, and consequently lighter, thaw-liquors from above. To an analogous procĕss, in its mechanical aspect, is due the freshening by rain of the ground-water of small, formerly submerged, oceanic islets.

Major T. ORDE LEES, R.F.C.: The question of ice-cracks referred to by the lecturer afforded a frequent theme of controversy at meals on board the *Endurance* during the long Polar night of 1915. The conclusions arrived at were, of course, merely surmise, but the opportunities afforded of observing the "working" of the ice under hitherto unprecedented conditions in the Antarctic enabled members to make certain logical deductions. These deductions, combined with a good deal of shrewd guessing, may be summarized as follows:

That the field-ice is subjected to a variety of influences exerting their effects relatively in the following order: wind, currents, change of temperature, crystallization. By far the most powerful factor is the wind.

Only very occasionally did cracks open out into lakes a mile or so across, and these lakes probably marked the approximate limit between the moving field and the fast ice. If a vast ice-field is in motion, it is probable that it is stretched out like a piece of sheet indiarubber, and as soon as its elastic limit is reached it cracks and contracts, which might account for the rapid widening of the observed cracks up to a certain point, for it was remarkable to witness the opposite edges of a crack recede from each other as much as 10 feet in a minute and then gradually stop as if the attenuated ice had reasserted itself. The effects of temperature may also cause variations of tension in the ice and therefore cracks. It is stated that the cracks occurring on the Great Lakes of North America are considered to be due mainly to temperature variations. The circumstances under which the ice crystallizes may have the same effect, slow freezing producing much larger crystals than rapid freezing; but this is merely conjecture. In some cases in the Weddell Sea there was ocular proof that certain cracks were directly due to the rotary motion of an ice-field. An angular movement of one degree or less over a space of 100 miles or so would of course cause an enormous disturbance accompanied by disruptive cracks. In these cases the edges of the cracks were generally observed to move in opposite directions longitudinally. It is also quite possible that the tides may have some effect on cracking ice, and certain that this is the case "in shore," producing what is called the tide-crack which fringes the Antarctic coast. The phenomenon of wide cracks occurring in apparently stationary ice in a dead calm and without any evident cause is a subject of great interest, but until simultaneous observations extended over a wide area become possible the matter must remain one of conjecture and deduction.

Mr. R. C. MOSSMAN: I have listened with a great deal of pleasure to Lieut. Wordie. His various points have been set forth in such an extremely clear way, and the general conclusions summarized in such a judicial manner, that it is very unlikely that he will have the experience that often befalls less cautious investigators, of having to eat his own words. Previous to the drift of the *Endurance* I was one of those who believed in the existence of Morrell's land, this belief being based partly on the very low temperatures experienced on the *Scotia* in March 1903 when in the vicinity of the hypothetical position of that

land, and also on the great contrast at the South Orkneys between west and south-west winds, the former being relatively mild and the latter extremely cold winds, during the continuance of which the temperature has been known to fall 40° Fahr. below zero, an extraordinary low value for an oceanic island in barely 61° S. lat.. The very congested ice condition off the Graham Land coast was another factor contributing to the belief there was something to the south-east and east holding up the ice. It is now however quite evident that an ice-bearing current analogous to the East Greenland current sweeps down the east coast of Graham Land, and that for all meteorological purposes the area covered by this current may be looked upon as continental, especially from about April to October, or even into November in some years, as suggested by the very low temperature in the last-named month found south of the South Orkneys during the four years 1911 to 1914. The isotherms drawn some ten years ago for the western portion of the Weddell Sea, based largely on Nordenskjölds Snow Hill data, indicated a cold area as lying off the east coast of Graham Land, this being due not to the influence of Morrell's land, as was assumed at the time, but to the large area covered throughout the greater part of the year by compact ice, that exerted to all intents and purposes a continental influence. Athough no vessel has been within 75 or 90 miles on either side of Morrell's land, the region within which it was supposed to exist has been practically circumnavigated, so that its obliteration from the map is now justified, unless it coincides with the Ross cluster of islands.

With regard to Lieut. Wordie's estimate that a winter's ice in the Weddell Sea amounts to about 5 feet, it may be remarked that in 1904, during my second winter at the South Orkneys, I found that in the 105 days (say 3½ months) ending August 31 the thickness in Scotia Bay 1 kilometre from the shore increased from 8 to 37 inches, while in 1909 the ice was 16 inches thick on June 4, increasing to nearly 7 feet on September 16—an increase of 63 inches in 104 days. The mean temperature during these two periods was respectively 11·5° and 13·8° Fahr. If we take the average of the two determinations we get 5 feet as the thickness of the winter's ice, so that I think Lieut. Wordie's estimate a moderate one, although we must bear in mind that the South Orkney measurements were made in a bay and not in the open frozen pack.

Mr. Wordie referred to the practical application of the Weddell Sea meteorology. By this I take it he refers to the relations between the weather conditions there and those experienced later over southern South America and South Africa. Some preliminary work in this direction has been available for some time, but these early results have been quite eclipsed by the discovery recently by a Mr. Hessling—a former colleague of mine in the Argentine Meteorological Office—that the temperature conditions at the South Orkneys from April to November (which may be called the winter season) in any given year are an index of the rainfall in various parts of Argentina some considerable time later. This relation varies in sign and period according to locality, but over the cereal belt of Argentina, which embraces the provinces of Buenos Aires, Cordoba, Santa Fé, and the Pampa Central, the maximum influence of the sub-antarctic winter conditions is experienced three and a half years later over the area in question. The correlation is positive, and the coefficients are very high, rising to about 0·90 in individual cases; that is to say, the rainfall is directly proportional to the southern temperature conditions. If you have a very cold winter at the South Orkneys, you will have a drought three and a half years later in the area under consideration. Now the winter period of 1915 was the coldest known at the South Orkneys, so that it follows that a severe

drought is due over the cereal belt of Argentina in the summer of 1918–19. As the winter period of 1914 was however mild, the coming Argentine harvest, particularly the maize harvest, should be abundant. The special mechanism by which the physical processes in Antarctica are related to subsequent meteorological phenomena over the southern continents is at present obscure, but is believed to be due to the varying temperature of the southern ocean brought about by the fluctuating quantity of polar ice, causing changes in the volume, direction, and intensity of the great ocean-currents, such as the cold Humboldt and Falkland drift on the one hand and the Brazil and Pacific equatorial currents on the other. Changes of ocean temperature affect the barometric pressure, as has been demonstrated in the case of the Bermuda anti-cyclone, which dominates winter conditions over the eastern part of the United States; and these alterations in the distribution of pressure lead to changes in the trajectory of the cyclonic and anti-cyclonic systems transiting the South American continent, which profoundly reduce or augment the precipitation. It is quite evident that the South Orkney winter temperature is largely influenced by the variations in the amount of ice brought down by the current which held the *Endurance* in its grip for so many months. In years when little ice is brought down the South Orkneys have an insular climate, but when there is much ice continental conditions prevail. The study of the physical conditions of the East Graham Land current is of great practical importance; especially to a country like ours, which has some 300 million sterling invested in Argentine interests.

It is a matter of great satisfaction that despite the extremely unfavourable conditions for carrying on scientific work during the perilous drift of the *Endurance* so much has been accomplished, and the important paper which we have had the pleasure of listening to is doubtless only a foretaste of the results that will continue to accumulate when Lieut. Wordie and the other specialists have had time to preface these reports. We must not forget that the gathering of the excellent results obtained owes much to the skill, energy, and encouragement of the leader of the expedition.

Dr. R. N. RUDMOSE BROWN: I was glad to hear that Mr. Wordie joins those who vindicate Morrell, even if the drift of the *Endurance* finally disposes of the existence of Morrell's land as a northward projecting peninsula of Antarctica. There is of course a possibility that Morrell's longitude was wrong, and that he had, as Mr. Wordie suggests, really landed on the coast of Graham Land. On the other hand it must be admitted that between the tracks of the *Endurance* and the *Deutschland*, in the position where Morrell claimed to have discovered land, there is plenty of room for a group of islands. The *Endurance* was not within 75 miles and the *Deutschland* not within 90 miles of the position Morrell gave. At such distances it would be impossible to sight land, and even at far closer range it might easily be missed, as in the case of Nicholas Land and Alexis Island lying in the Arctic Ocean a few miles north of Cape Chelyuskin. Though several ships, including the *Vega* and the *Fram*, had rounded that Cape, these islands were never even suggested until a few years ago. Until direct evidence of the non-existence of Morrell's land is forthcoming, we have no right to expunge his discovery from the chart. A careful examination of Morrell's narrative of his voyage in the Weddell Sea will convince any one familiar with the conditions in that region that Morrell was no impostor, and that there are no grounds for the attacks on his veracity. Furthermore, Ross's "strong appearance of land" in about 65° S. and between 45° W. and 49° W. lends support to Morrell, for Ross was a

navigator of experience and one who was very careful in reporting land. His other reports of land in the Ross Sea have been proved by Scott to be true to fact.

The Weddell Sea is probably bounded by broken plateau edges, and the continental shelf as described by Mr. Wordie has a step-like structure suggestive of the same nature. It is therefore quite possible that on a wide continental shelf certain portions of the plateau had remained above water and formed islands or clusters of islands. Such islands would probably have deep water near inshore. The suggestion of a strait across the southern part of Graham Land is not accepted by Mr. Wordie, who considers that the course of the drift and the ice conditions in the Weddell Sea disprove it. There never was any satisfactory evidence of such a strait, and it will be surprising if it is found to exist. The tectonic nature of Graham Land, a region which has experienced depression and drowning decreasing from north to south, is a strong argument in favour of its continuity with the main land mass of Antarctica. Biological evidence derived from a comparison of the fauna of the Weddell Sea with that of the Bellingshausen Sea is also opposed to the existence of such a strait. The drift of the *Endurance* is further evidence in favour of the northerly drift in the west of the Weddell Sea which Bruce maintained after his return from the *Scotia* expedition. It is of interest to hear that the Shackleton expedition obtained data from which it is hoped that the rate of this drift can be computed. The existence of this drift and the ice-congested state of the Weddell Sea make it the most difficult region of the Antarctic to penetrate and explore.

Mr. HINKS: I would like to say one word on the question of the occultations, to which Lieut. Wordie has briefly referred. When we heard that the expedition had come back from the Weddell Sea with ten well-observed occultations of stars, with Mr. Wordie's permission I asked the Astronomer Royal if he would be good enough to have the observations recomputed by Dr. Crommelin. The reason why it was necessary to do this was not the possibility that the original reductions might be imperfect, but because, as is fairly well known, the place of the Moon in the Nautical Almanack is not the place of the Moon in the sky. For a reason which one cannot explain the Moon of late years has been running away considerably from its predicted place in the Nautical Almanack. Thus wherever there are occultations of a critical value it is always necessary to have them recomputed with the observed place of the Moon. This has now been done for the observations taken in the Weddell Sea, by the kindness of the Astronomer Royal and Dr. Crommelin at Greenwich; and I think the Society would like to express their thanks for this courtesy.

Lieut. J. M. WORDIE: I would like to say a few words with regard to Morrell. It seems to me that there are three different schools. There is Sir Douglas Mawson, who says that Morrell was a humbug; I try to be lenient to him, and explain everything away; while Dr. Rudmose Brown is, I think, rather too keen an upholder of Morrell.

Prof. RUDMOSE BROWN: I do not mean to go further than you do.

Sir DOUGLAS MAWSON: I do not mean to say that Morrell purposely told stories. I mean to say it did not matter at all to him whether he was correct or not.

Lieut. WORDIE: I do not want to admit even that cluster of islands, and I think Prof. Brown does. There are two things which rather disprove the cluster of islands: one is that our ship was not held up in any way when

the winds were driving it in that direction; the other is the error of longitude, and I do not see how Prof. Brown is going to get over that.

The CHAIRMAN: We are very much indebted to Lieut. Wordie for taking part in the discussion, and for giving us quite a lively afternoon; perhaps in the future we will have a little more amusement out of Morrell.

HALLEY'S MAGNETIC VARIATION CHARTS

E. A. Reeves

NOTE by the Editor, G.J.—At the first meeting for the discussion of Geophysical questions arranged by a committee of the British Association, and held at the Rooms of the Royal Astronomical Society on Wednesday, November 7, Dr. S. Chapman of the Royal Observatory, Greenwich, gave an account of the history of terrestrial magnetism, and showed on the screen a photograph of Halley's Atlantic Chart, which he described as forgotten until Dr. Bauer (*Nature*, 23 May 1895, p. 79) called attention to a copy in the British Museum. In the following January Dr. Bauer reproduced on a small scale in *Terrestrial Magnetism* a second copy of the chart in the possession of Mr. Thomas Ward of Northwich.

After the meeting I was talking to Mr. W. H. Wesley, assistant secretary of the Royal Astronomical Society, in his room, when I noticed on the wall a copy of the Atlantic Chart, which had hung there certainly since 1872. On the following morning I asked our Map Curator if we possessed a copy. We did not, but within a day or two he succeeded in buying one which proves on examination and comparison with other copies to be of interest, as probably the earliest. At my request, therefore, Mr. Reeves has written the following note. A. R. H.

I have compared the copy of Halley's "New and Correct Chart showing the Variations of the Compass in the Western and Southern Oceans," now known as his Atlantic Chart, which has just been purchased for the Society, with early copies in the Map Room of the British Museum and at the Royal Astronomical Society, and find that they are evidently all from the same plate, with the engraver's name "I. Harris" at the bottom: but there is one important difference. Our copy lacks the dedication to King William III., the space for it within the frame being blank. On close examination it is clear that the dedicatory inscription cannot have been erased from the plate before our copy was printed, as the engraver's "spacing out" lines are all plainly visible across the blank space, as well as in other parts of the plate. It would seem, therefore, that the Society's copy is an earlier impression than either of the others. It does not bear the names of Mount and Page under the engraved title as the Astronomical

Society's copy does, nor does it seem ever to have had the columns of explanatory text pasted on it which some other copies have. So far as I have been able to ascertain no other copy exists with the space for the dedication blank, so it may be that the Society possesses the earliest known copy of this interesting chart. It is probably a proof pulled from the plate before publication, and before the dedication was written. It is in excellent condition, and the lines and lettering remarkably clear.

The dedication to William III. fixes the date of this Atlantic Chart very closely. Its full title is "A New and Correct Chart showing the variations of the Compass in the Western and Southern Oceans as Observed in y^e^ year 1700 by his Ma^ties^ Command by Edm. Halley." The voyage of the '*Paramour* pink' ended on 7 September 1700, and it is not likely that Halley had time to prepare his magnetic observations, to draw the chart, and to get it engraved before the end of that year. But William III., under whose orders the voyage was undertaken, and to whom the chart is dedicated, died 8 March 1702, so the chart in all probability was engraved and published in 1701.

It is certainly remarkable that Halley never referred to this chart in any of his writings; but this may be due to the fact that he considered it as only preliminary to his world chart, which includes the variation lines for the Indian Ocean as well.

Although the world chart is well known, the Atlantic chart seems to have been entirely overlooked until Dr. Bauer called attention to the copy he had seen in the British Museum. This is more remarkable since other early copies of the chart have since come to light. The chart was re-published (the later copies with the chart re-engraved) several times during the eighteenth century, and appears, with corrections to bring it up to date, in a number of editions of 'The English Pilot' (fourth book), which was first published by W. Fisher and J. Thornton in 1689 (too early for the chart) and later by Mount and Page. Dr. Bauer wrote further notes on the chart in *Terrestrial Magnetism* (vol. 1, p. 28 and vol. 18, p. 115). His photographic reproduction of an early copy lent by Mr. T. Ward of Northwich is similar to the British Museum, R.G.S., and R.A.S. copies, except that the R.G.S. copy has no dedication. The R.G.S. possesses one of these later editions (corrected to 1744) with Halley's text and additions pasted on in strips at the side, sold by W. J. Mount and T. Page & Sons on Tower Hill, and I have inspected three or four editions of the 'English Pilot' containing the chart at the shop of Messrs. Stevens & Styles, the well-known second-hand booksellers of Museum Street, Bloomsbury. The earliest edition of the atlas with the chart they now have there is dated 1749, but they have had much earlier, and the British Museum has a copy of the atlas of 1737 with the chart, from the original Harris plate. Among those who copied this Atlantic chart, re-engraved it, and published it in their edition of the 'English Pilot,' was George Grierson of Dublin, in 1730–1749. The chart is missing from

many copies of the 'English Pilot,' and has probably been taken out by mariners for use at sea.

Thus, although the original impressions of the Halley's Atlantic Magnetic Variation are rare, corrected copies published later during the next fifty or sixty years are fairly common.

The relative dates of Halley's Atlantic and World Magnetic Charts is an interesting question. Dr. Bauer discusses it in his notes referred to, and comes to the conclusion (*Terrestrial Magnetism*, vol. 1, p. 30) that the World Chart could not have been published in 1701, as has been supposed, but somewhat later, probably in 1702. The Royal Geographical Society has no copy of the original edition, which is rare, but has recently bought a copy of Halley's World Chart, with corrections to 1756, by W. Mountaine.

I have lately compared the Society's copy of the Atlantic Chart with those in the British Museum, and with their original copies of the World Chart (they have two at least, besides others of later date), to see what evidence could be found of their respective dates; and on the whole I agree with Dr. Bauer's conclusions. As he points out, the World Chart must be later than the Atlantic Chart, since it is dedicated "To His Highness Prince George of Denmark, Lord High Admiral of England, Generalissimo of all Her Majestie's Forces." Prince George, who was the consort of Queen Anne, did not bear this title until 17 April 1702. He died on 28 October 1708.

The difficulty as to the date is due chiefly to the statement made by Halley (*Phil. Trans.*, vol. 19, unabridged, 1714, p. 165), in which he says that he has "to examine the chart I published in 1701 for showing at one view the Variations of the Magnetical Compass in all those Seas with which English Navigators are acquainted." The last words of this statement would seem to refer to the World Chart, and not to that of the Atlantic; and yet he says that the chart was published in 1701, which is inconsistent with the dedication to Prince George of Denmark. Dr. Bauer thinks that either Halley made a slip in the date when he wrote 1701, or that there may be an earlier edition of the World Chart not yet come to light, published in 1701, from which those at present known were copied, with a new dedication.

In talking this matter over with Mr. de Villiers of the British Museum, we came to the conclusion that, as he suggested, the solution may lie in the fact that at that time, owing to the New Style not having yet come into legal use, and the year not beginning until March 25, the first two and the greater part of the third month of 1702 would be reckoned as belonging to 1701. It is thus possible that Halley may have prepared the World Chart for publication quite early in 1702, which would then be reckoned 1701, and have added the dedication a month or so later, after Queen Anne's accession and Prince George's assumption of the offices described.

An interesting point that seems to have escaped Dr. Bauer's notice is

that the variation lines on the Atlantic and the World Charts are not exactly the same in some places. Although the difference is very slight, and might at first be taken for inaccuracy in drawing, I am inclined to think that they are intentional, and meant to be corrections to the lines for the interval of time between the drawing of the two charts. Halley in his notes states that in one part the change in the variation amounts to a degree in seven years, and in another to a degree in eleven or twelve years, so that, since the degrees of variation on the chart are separated by a fairly large space, often over half an inch, the amount of annual change would be quite appreciable. I have found in the few cases that I have compared that the difference is roughly consistent with the change, supposing the Atlantic Chart to have been drawn early in 1701, and the World Chart nine months or a year later. As Dr. Bauer points out, the two charts are not from the same plate, as will be seen at once from the considerable discrepancies in the outlines of the coasts, and the lettering of names.

THE WORK OF COMMANDANT TILHO IN TIBESTI AND WADAI

THROUGH the courtesy of M. Charles Rabot, editor of *La Géographie*, we are able to publish a brief account of the remarkable work carried out by Commandant Tilho between Tibesti and Darfur during the last five years. By a fortunate combination of circumstances Commandant Tilho has been placed in a position to combine the establishment of French authority in these little-known regions with geographical reconnaissance of the first importance, and to extend his well-known work in the neighbourhood of Lake Chad right through the almost unknown country north-east and east to connect with the Anglo-Egyptian Surveys at El Fasher. It is the most considerable contribution to the geography of Africa which has been made for some time, and has particular importance in view of certain floating ideas as to a possible connection in the past between the Nile system and the system of Lake Chad.

In June 1912 Commandant Tilho, being appointed to the command of Kanem, was entrusted by the *Académie des Inscriptions et Belles Lettres* with the task of extending his surveys and geographical inquiries whenever military duties allowed. Soon after his arrival he distinguished himself in the capture of Ain' Galakka, the principal stronghold of the Senussi in this country. By the middle of January 1914 the military operations were finished, and Commandant Tilho was ordered to Faya to organize the newly occupied territories of the district Borku-Ennedi. As it turned out, these operations against the Senussi in the west had very important consequences in destroying their advanced western base and making it impossible for them to operate with the neighbouring Germans in the

THE LAKE OF UNIANGA

ROCKS OF TONGUR, VALLEY OF MISKI

THE GORGES OF ARSHEI, ENNEDI

ENTRANCE TO THE LARGE
CAVE, GORGE OF ARSHEI

ENTRANCE TO THE GORGES
OF DURDURO, ERDI

ROCK CISTERN IN ERDI

Cameroons at the outbreak of the war. Instead of this the Senussi's adherents found themselves between the French advancing from the west and the Anglo-Egyptian forces from the east, and their fate as accomplices of the German-Moslem campaign is now a matter of history.

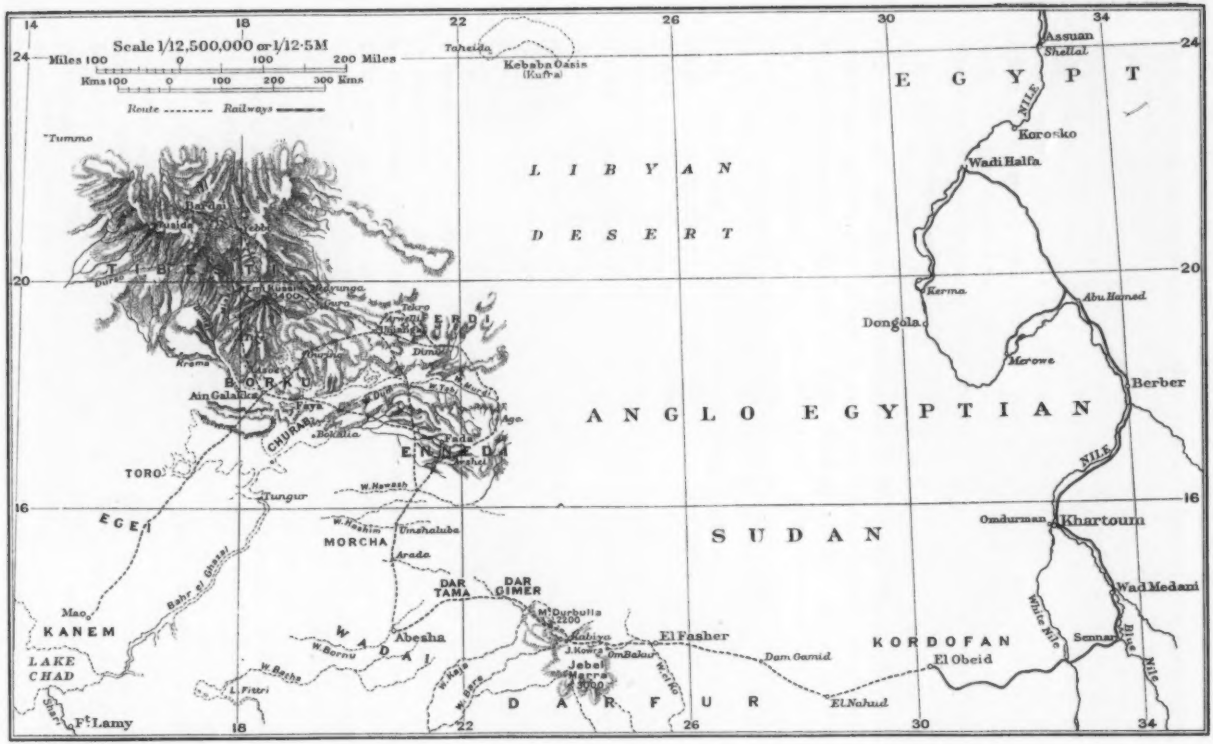
Commandant Tilho was well known in the past for his excellent astronomical determinations of position. During latter years he has been able to improve his operations by the receipt in the field of the wireless time-signals from the Eiffel Tower, and we shall look forward with much interest to a study of his published results, for this method opens up great possibilities of a rapid improvement of maps in countries where triangulation is from the nature of the ground both difficult and unprofitable.

Borku he describes as a confused mass of sandstone, partly buried in sand, and so greatly denuded by the north-east wind that the old relief has almost disappeared. Vegetation is scarce, and grazing for camels scanty, but the country supports from six to eight thousand people, of whom half are sedentary. In October 1914 the Commandant visited the north-east frontier, about 400 kilometres from Faya, determining many positions, and describing particularly the remarkable lakes of Unianga, of which two, fed by springs, have an area of more than 500 hectares, and one contains freshwater fishes. Except in this neighbourhood the whole country is uninhabited, and vegetation even scantier than in Borku. Thence he went east to the district of Erdi, a land rising in terraces eastward to 600 or 800 metres above the plain of Borku. Here there are no oases, but only occasional water-holes, yet the camel-grazing is better. This district was the refuge of tribes who had not acknowledged French jurisdiction, and who not only molested the caravans on the French communications, but did not hesitate to raid the camels of Dongola and Kordofan, 700 kilometres across the desert.

Passing thence south towards Ennedi, Commandant Tilho crossed a depression running south-west and north-east for more than 60 kilometres, of which he had heard before as a prolongation of the broad wadi of the Bahr el Ghazal, by which Lake Chad was connected formerly with the old lakes of Jurab and Toro. Here if anywhere would be found the ancient valley by which it has been supposed that the Nile and Lake Chad were connected, and he gave therefore particular attention to this region. But the lowest point of this broad depression between Erdi and Ennedi is at least 300 metres above the level of Lake Chad, while the structure of the country confirms the conclusion based upon these heights, that the idea of a connection here is baseless. This important point settled, Commandant Tilho turned to the high plateau of Eastern Ennedi, which is a triangular mountain mass of sandstone, with deep and picturesque gorges, and heights running up to 1500 metres, inhabited by small but bold and unsubdued tribes; thence he moved south-west to study the watercourses descending its western flank towards the old lake-basin of Jurab. In these river-beds there is water for only a few days each year, but they run for

OF DURDURO, ERDI

ENTRANCE TO THE LARGE CAVE, GORGE OF ARSHEI


Scale 1/12,500,000 or 1/12·5M
Miles 100 0 100 200 Miles
Kms 100 0 100 200 300 Kms
Route ------- Railways
Tummo
Tarso Toon
Kebaba Oasis (Kufra)
L I B Y A N
D E S E R T
E G Y P T
Assuan
Shellal
NILE
Korosko
Wadi Halfa
Kerma
Abu Hamed
Dongola
Merowe
Berber
A N G L O E G Y P T I A N
S U D A N
Omdurman
Khartoum
Wad Medani
Sennar
Blue Nile
White Nile
Tibesti
Bardai
Yebbi
Trou
Ain Galakka
Faya
Largeau
Ounianga
Kebir
Aozou
Ago.
Bokkoye
Tekro
Dirkou
Agadem
Kalaa
Krama
Dirkou
Mangueni
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Bilma
Kaouar
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200 or 300 kilometres, and are eventually lost in marshes which lie about 100 metres above the level of the old lake-bed. Further north, in the region of the Wadi Dum, he found an old zone of lakes situated decidedly higher than Jurab, but lower than the depression further east which has been described above. All the old watercourses of this region, as well as those of Tibesti, converge towards this old lake zone, which is connected with Jurab by a perfectly clear channel. Commandant Tilho concludes that the basin of Jurab is a closed basin without communication with the Nile, but that there existed formerly in the middle of Africa a region of lakes and marshes with an area larger than that of France, of which Chad in the south-west and the lakes of Unianga in the north-east are the last remains. The question suggests itself whether this represents the famous Chelonides of the old geographers.

In September 1915 Commandant Tilho started with a small party and escort for a further exploration of Tibesti, especially of the old volcano Emi-Kussi. The crater is 12 kilometres long and 8 broad and 400 metres deep, with two vents, of which the principal is 2½ kilometres at its mouth and 1 kilometre at the bottom, 300 metres below the floor of the crater proper. At the bottom is a layer of sodium carbonate, about 50 hectares, and pretty thick at the centre; a boring of 1·50 metre deep did not find the bottom. There is no trace of water. From the principal summit of the crater wall one can see the peak Tusida and the highest summit of Tibesti, 200 kilometres away. The exterior of the crater is bare, but inside there were several stretches of ground covered with flowers.

Proceeding north through the valley of Miski, Commandant Tilho then visited the oasis of Bardai, first described by Nachtigal forty-six years before. The principal peaks of the western chain of Tibesti were fixed, and the position of Bardai was found to be nearly 100 kilometres further north than that estimated by Nachtigal. This mountainous region is difficult, and the inhabitants inclined to be troublesome. Copper was found, but its richness was not determined.

The reconnaissance showed that the mountains of Tibesti are not a simple chain running north-west and south-east, but are in four or five chains directed from west through north to north-east in a fan-like formation centred on Emi-Kussi. With the aid of the energetic and capable topographers of his staff Commandant Tilho has completed a map on the scale of 1/million, which will make a notable contribution to our hitherto extremely deficient knowledge of this region.

In 1917 the time had arrived for Commandant Tilho to bring to an end his long service in Africa. At his request he was allowed to complete his geographical work by making the long-desired connection with the Nile Survey. In April, therefore, he handed over his command and started on his return home *viâ* Wadai and Darfur. At the end of May he arrived at Abesha, by way of Um-Shaluba and Arada, finding many of the villages deserted after the great famine of 1914. Abesha has to-day

no more than four or five thousand inhabitants. Turning east towards Darfur, Commandant Tilho took a route north of the usual caravan road, and through unknown country, where he was able to fix several positions in Dar-Tama, and to traverse Dar-Gimer. The former is a granite plateau from 900 to 1000 metres high, dominated by a series of isolated peaks, of which one reaches 1400 metres. It is pleasant country, with many wooded valleys where rivers run for several weeks each year, tributaries of the Bahr–Salamat on the southern slope, and of the Mahamid country, apparently an inland drainage basin, on the north. Population is comparatively dense, and much agriculture is practised.

Gimer is a flat, bare, and thinly peopled region, with little cultivation, but fine herds of cattle. The shallow valleys descend from the plateau of Tama on the west, and from the western slope of the mountains of northern Darfur on the east. They are waterless in the dry season and marshy in the rainy season, and communications are bad between the months of August and December. West of the large valley of the Bahr–Salamat (called in this region Wadi Kaja) is a high chain of mountains whose principal summit, Durbulla, reaches the height of 2200 metres; and the chain continues south to Jebel Marra, which is about 3000 metres high, though hitherto shown as no more than 1800 metres. Here Commandant Tilho passed the frontier of the Anglo-Egyptian Sudan, and at Kabiya was received by the officer in command of the first British post. In Kabiya at the end of June the sky was cloudy and heavy rain fell, the clouds coming from the south-south-west and watering abundantly the mountain barrier east of Kabiya. The passage of the mountain chain between this place and El Fasher presented no serious difficulty. The cols are numerous and low, the ground is stony, and the track is cleared a dozen metres broad. The summit of the route is at the col of Kowra, at 1200 to 1300 metres, where a region of salt begins which extends to Um-Bakur. In this region there is volcanic débris above the granite and schist. Jebel Marra is perhaps an ancient volcano, but only the lower slopes have been explored. The upper slopes and summit are held by independent tribes, and here is the cradle of the family of the ex-Sultan Ali Dinar. Colonel Savile, Governor of Darfur, says that by native report there is a large lake on the top of the mountain.

At Darfur Commandant Tilho made his last astronomical observation, and closed his chronometric series on the longitude determined a little while before by telegraph from Khartum by Mr. Pilkington, of the Sudanese Survey. The error of closing was only 22 seconds of time after a journey of seventy-five days extending over 1200 kilometres. During a stay of twelve days at El Fasher the Commandant was able to conclude with success the mission entrusted to him by the Governor of Chad, to arrange for the policing of the Anglo-French frontier.

El Fasher is described by Commandant Tilho as a town of 1500 to 2000 people, the finest native town that he has seen in Central Africa,

built on dunes surrounding a depression partly flooded in the rainy season, and where in the dry season people dig hundreds of wells. The palace of the ex-Sultan is a fine building, almost entirely of local materials, and a very remarkable work; but the kingdom of Ali Dinar was ruined to embellish the capital, and his people reduced to slavery.

The concluding sections of Commandant Tilho's Report deal with his journey from El Fasher to El Nahud, El Obeid, and so to Khartum. He speaks in grateful terms of the cordiality with which he was received by the British officers at each stage of the journey; and they, we are sure, were delighted to celebrate the immense change which has taken place in our feelings towards our excellent friends and allies since the last French officer arrived in these parts from the west only twenty years ago. So ended under the most auspicious circumstances this very fine piece of geographical work, by which the great problem of an old connection between the basins of Chad and of the Nile is definitely settled in the negative; by which a belt of country nearly 1800 kilometres long, from Bardai in Tibesti to Kabiya in Darfur, is for the first time thoroughly reconnoitred; and a geographical connection established between the Niger and the Nile by a chain of astronomical positions reinforced by wireless telegraphy.

Thanks to Monsieur Rabot, we are able to publish a sketch-map and some photographs to illustrate this preliminary account of Commandant Tilho's excellent work. An article by M. Rabot, illustrated by many other interesting photographs, appears in *L'Illustration* for March 2.

BRITISH INTERESTS IN SPITSBERGEN

A CLAUSE in the "Russo-German Peace Treaty" made at Brest Litovsk between the Bolshevik Government and the Imperial German Government has brought into prominence the German intention of claiming a position in Spitsbergen to which she has no right, either by her pre-war position there, or by succession to a share in any Russian interests which the Bolsheviks may have been pleased to give away. More than a year ago the position of British interests in Spitsbergen was the subject of anxious consideration by the Council of this Society; and on 10 January 1917 a letter and memorandum were addressed to the Secretary of State for Foreign Affairs which, with his reply, are by permission of the Foreign Office now printed below. The Council believe that this publication may serve a good purpose in bringing to public notice the great importance of British interests in Spitsbergen and the inadmissibility of German-Russian claims to any standing in the archipelago.

I. *The President of the R.G.S. to the Secretary of State for Foreign Affairs.*

Royal Geographical Society, Kensington Gore, London,
10 January 1917.

SIR,

I am requested by the Council of the Royal Geographical Society, of which I have the honour to be President, to submit for your consideration the following Resolution, passed by it on December 18th last:

> The Council of the Royal Geographical Society begs leave to represent to His Majesty's Secretary of State for Foreign Affairs the importance of taking immediate steps to safeguard British interests, political, strategic, and commercial, in Spitsbergen, and to urge that the matter be adjusted with our Allies before the termination of the war.

The Council desires to call your attention to the importance from several standpoints attributable to Spitsbergen—an importance due to its geographical position, to its relative proximity to the British Isles and an important trade route, and to its extensive deposits of steam coal and other minerals. It can hardly be necessary to insist on the dangers consequently likely to arise from the absence of any definite sovereignty or control over these islands, where large interests are already possessed by British subjects.

The Council has further asked me to forward with the Resolution this statement setting out briefly some of the grounds which have influenced it in regarding the matter as one of urgent importance at the present time.

The facts of the case, historical and geographical, are fairly simple.

A summary of early events connected with the islands, drawn up by Sir Martin Conway, is given in the Appendix attached. From this it is clear that Great Britain asserted and maintained for over half a century (1614 to 1670 about) an effective and admitted occupation of the southern half of the main island from King's Bay downwards. This is the region which is most adaptable to human use, and contains the coal-bearing districts. Holland in the same century asserted a claim to the northern part of the main island. In the first half of the nineteenth century Russian trappers visited both the British territory and the eastern island.

Great Britain has therefore an undoubted historical claim, superior to that of any other nation, to sovereignty over the islands, or at least over the most important of them.

No other countries have anything beyond commercial properties and rights, created by occupation and user.

The first and most essential geographical factor in the situation is that a large group of islands, permanently habitable, and accessible to vessels during four or five months in the year (probably with ice-breakers during

the whole year): islands containing large and valuable deposits of coal, almost equal in quality to the best Welsh steam coal, and situated only some sixty to seventy-two hours' steam from Scottish ports, are under no jurisdiction whatever. Spitsbergen is a *terra nullius;* property acquired by occupation is at the mercy of the strongest new-comer; might is right; there is no security against or redress for wrong-doing. Disputes and contests have consequently arisen from time to time between the miners and trappers, English, American, Norwegian, Swedish, and Russian, who claim rights to the island. This state of things, as the Council is informed, led to an International Conference, having for its object the establishment of some form of Joint Control, similar in kind to those which have been tried with unfortunate results in the islands of the Pacific, being held at Copenhagen shortly before the war. That conference broke up without coming to any conclusion, largely owing, it is understood, to the pretensions put forward by the German delegate.

The Council believes it may be fairly assumed, from the fact of Great Britain having taken part in such a Conference, that in the opinion of H.M. Government the establishment of some supreme control over Spitsbergen had become, before the war, a political object of serious and pressing importance.

The Council would now therefore venture to urge, in view of the failure of the Conference, that the only satisfactory way of meeting the situation is for H.M. Government in agreement with our Allies to take such steps to settle the future of Spitsbergen as they may deem expedient, either by proclaiming the sovereignty of Great Britain over the islands, or over that part of them to which, since its annexation in the seventeenth century, we hold an historical claim superior to that of any other nation.

The inconveniences (to use a mild term) of the absence of any responsible government in Spitsbergen already pointed out are not the only ones. There are other dangers, political and strategic. Spitsbergen before the war had been used for wireless stations both by Germany and Norway. Germany has, it is reported, sought to acquire a harbour there. Lying, as it does, at no great distance from the track of vessels plying to the new ice-free port of Russia, to Archangel, and to Siberia, it may in the future serve as a convenient base for submarine activity on a trade route that is bound to grow in importance.

The Council has not overlooked reasons that may possibly be urged against any definite and decided action, such as the inexpediency of increasing our naval responsibilities, or the risk of subjecting to any extra strain our delicate relations with Scandinavian neutrals. It desires, however, to put on record its conviction that if no action is taken before the end of the war the difficulty of dealing with the situation in Spitsbergen will be greatly increased, and this country may have cause to regret the delay. The recent reported action of Russia with regard to other islands in the Arctic seas may be held to indicate that our Ally considers the

present a time for safeguarding the future by removing the risks inevitably arising from unclaimed, or disputable, territories.

I have the honour to be, Sir,

Your obedient servant,

DOUGLAS W. FRESHFIELD,
President.

APPENDIX

The references are to Sir Martin Conway's book 'No Man's Land,' Cambridge University Press, 1906.

17 June 1596. Spitsbergen was discovered by Dutch ships under the command of Wm. Barents. They landed on the 21st, and set up the Dutch arms on a post in Fairhaven. No attempt was made by the Dutch to utilize this discovery.

27 June 1607. Pp. 22 ff. Spitsbergen was rediscovered by an English Expedition under Henry Hudson. He landed in King's Bay. It was in direct consequence of this voyage that the English Company of Merchant Adventurers made Spitsbergen their whaling base for a series of years thereafter. In consequence of the profit thence derived the Dutch followed them, and thereafter when troubles arose, claimed rights owing to priority of discovery.

P. 33, 1610. The first English whaling expedition to Spitsbergen. A base was established in a branch of King's Bay.

P. 43, 1611. Second English voyage under charter of exclusive rights from the Privy Council.

P. 48, 1612. Third English and first Dutch whaling voyages, the Dutch being piloted up by English deserters.

P. 51, 1613. The Muscovy Company received a charter from James I., giving them a monopoly of the Spitsbergen fishery. A great number of interloping Dutch and other foreigners intruded on the fishery, and there was fighting.

Pp. 65 ff., 1614. The Dutch formed a strong Whaling Company, and *de facto* obtained possession and thenceforward held the bay and islands at the north-west corner of Spitsbergen. There they built a kind of summer town of considerable size. The English *de facto* from this time forward held the bays to the south from the King's Bay group down to Horn Sound. Some Hamburgers, Danes, and Frenchmen occasionally settled in the Dutch area, but none in the English. In this year the English took possession in due form of various sites in what was to remain their sphere of influence. *This year King James formally annexed Spitsbergen, and named it King James his Newland.* The Dutch refused to recognize the English annexations, and by force maintained their partial occupation of the north-west corner. There was in this year an informal understanding arrived at in practice between English and Dutch on the above lines. For some years there were struggles and encroachments by one nation on the other, but no disturbance of the practical division.

1618. After further troubles, in the winter Dutch Commissioners were sent to England, and the diplomatic negotiations proceeded.

July 1619. In Merchant Taylors' Hall King James' decision was pronounced. He adhered to annexation but agreed to a three years' truce, English and Dutch to settle in their respective areas as in practice arrived at—Dutch at the north-west

1634. corner; English in all the other west coast bays. The traced map in Sir Martin Conway's atlas deposited in the Royal Geographical Society's Map-room has an official line marking the division of the areas, by Michael Harmensz. Middelhoven, 1634, in Rijks Archiv, The Hague (No. 2).

P. 133. A long official report of discussions between Dutch and British Captains as to the termination of the three years' agreement. The Dutch refused to recognize its termination, and it was in fact thenceforward upheld as long as the fishery lasted.

P. 142, 1626. About now and henceforward there were quarrels between Londoners and Hull and other townsmen as to rights in the English sphere.

P. 367. Henceforward the English maintained their hold on the west bays of Spitsbergen without practical interference from the nationals of any other country. A list of English harbours as owned in 1658 is in State Papers, Domestic, Interregnum, vol. **179**, Jan. Feb. 1658, No. II (2). When the bay-fishery for whales ceased, Spitsbergen was no longer occupied.

In the nineteenth century only scientific and hunting expeditions visited Spitsbergen, and some of both sorts wintered but these were only passing visits, and do not affect the old and substantial British claim.

II. *The Secretary of State for Foreign Affairs to the President of the R.G.S.*

Foreign Office, 7 March 1917.

SIR,

With reference to your letter of January 10 last, submitting a resolution passed by the Council of the Geographical Society, representing the importance of taking immediate steps to safeguard British interests in Spitsbergen, I am directed by Mr. Secretary Balfour to state, for the information of the Council, that the question of Spitsbergen, which cannot be decided without discussion with several foreign Governments, is not one in which any definite settlement can be come to now, as the present moment is not opportune for bringing forward matters of this nature.

The question will, however, not be lost sight of, and in any settlement which may eventually be arrived at British interests will be most carefully borne in mind.

I am, Sir,
Your most obedient, humble servant,
R. GRAHAM.

DISCUSSION ON MR. HARDING KING'S PAPER "STUDY OF A DUNE BELT."

At the Afternoon Meeting of the Society, 21 January 1918.

[The paper had been published already in the January number of the *Journal*. At the meeting the author read an abstract of the paper, with many additional illustrations, and a discussion followed.]

The CHAIRMAN (Dr. H. R. Mill): I think we have to congratulate Mr. Harding King on giving so concise and excellent a summary of his paper. I will limit myself to asking two questions out of many that suggest themselves. One arises from the last point he referred to us—the origin of the long narrow belt of dunes. It is difficult for me, accustomed to wind in its meteorological aspects, to understand how wind blowing through a narrow opening fails to spread out like a fan and grow weaker as it advances. It is a little difficult also to understand how, if the normal mode of progression of these dune belts is by the development of new crescentic dunes off the horns of existing dunes, the resulting series should not acquire rather a fan-shape than that of a long straight belt. I should like to know whether the sand adaptable for such dune building in the desert naturally lies in straight belts separated by ground of a different character. That might possibly have something to do with the occurrence of these forms. The other point that I should like a little more light on is the crusting of the sand. I presume from the paper that the crusting is due to cementing by calcareous matter, and in order that this should form a crust it must first get into solution. One would therefore expect a crust to be formed during the infrequent rain-storms that occur in that region. That might account for a belt of strongly crusted sand being formed perhaps during exceptionally heavy rain and persisting for several years. But how could it persist in a travelling dune? Does the sand build over the crust so as to tend ultimately to form a sort of laminated structure of alternating crust and soft sand? Or does the crusted portion stay still and let the fresh sand drift over it? Dr. Vaughan Cornish has found it possible to return in time to take part in the discussion, and as he has studied these matters with great detail, and especially as his views have been somewhat strongly contraverted, I call upon him for his comments on the paper.

Dr. VAUGHAN CORNISH: It was only two days ago, on my return from a month's lecturing tour of the British Army and Corps Schools in France, that I saw the January number of the *Journal* containing Mr. Harding King's "Study of a Dune Belt," with its valuable diagrams of the plan and profile of carefully measured crescentic dunes, and its discussion of my paper "On the Formation of Sand Dunes," contained in the *Geographical Journal* of March 1897. One difficulty attending the discussion of observations on these phenomena is that of making sure that the conditions with which two observers deal are comparable, and I could not, without more time than I have now at my disposal, undertake to say if that is or is not the cause of the discrepancy which Mr. Harding King notes; but apart from this, I must point out that the statement that my "views on the subject of these eddies are given in the paper 'On the Formation of Sand Dunes,' *Geographical Journal*, vol. 9, p. 298," needs amendment. My views on these matters are to be found in a publication of fourteen years later: a treatise on 'Waves of Sand and Snow,' published

in 1914, in which the observations recorded in earlier papers of the *Journal* are reviewed in the light of those contained in the later, including that on snow-waves. Two fundamental facts which emerged with increasing clearness as the investigations proceeded I brought out in the book, and I desire now to emphasize again. The first is that the conception of a series of transverse ridges of incoherent granular material travelling in connected and dependent sequence as a group of forced waves is legitimate, and has proved fruitful. Starting from the general conceptions associated in literary English with the word "wave," I have shown that these can be scientifically developed along two different lines; first, that already familiar in physics, applicable to periodic pulsations propagated elastically through the bulk of media; and second, that applicable to a series of transverse superficial inequalities, whether travelling freely, as the ocean swell, or partly forced and partly free, as waves at sea during a storm, or wholly forced, as the transverse ridges in loose sand or dry snow.

The phenomena of drifting sand and snow, however, are not confined to cases where the inequalities form long transverse ridges, for it often happens that the quantity of loose material is insufficient to cover the ground. Then we have to do with patches of loose material which forms heaps of diverse but inter-related forms. These are sometimes travelling and sometimes stationary mounds, the latter being formed in the neighbourhood of a fixed object projecting above the ground. In these cases the fundamental fact is that there is a curved surface with a boundary of a definite character into which the heaps fit. This curved surface is the margin of an eddy. The great variety in the shape of the mounds is mainly due to the circumstance that in different cases different proportions of the eddy-space have been filled in. In snow-drifts especially is the supply of material frequently inadequate. There are moreover two sets of shapes: those of the fixed and those of the moving drifts. The former when complete, *i.e.* when the whole eddy-space has been filled in, have a blunt bow at the windward end, and a fine stern at the lee. Thereafter the wind blows over the surface without eddying, and therefore with the greatest possible ease. The drifting mounds, when the material is perfectly loose and incoherent, show fine lines on the windward and a blunter lee, their form thus increasing the eddying of the wind. As they increase in size the lower layers become compacted and the mounds then approximate to the conditions of those caused by fixed obstructions.

Mr. Harding King has referred to my remarks on the analogy between the curves of snowdrifts and those of vessels. When, however, he speaks of the instruction to be derived from a race between a boat built on "wave-lines" and one on "dune-lines," I would point out that the eddy-curves of snowdrifts are those appropriate to aircraft and submarines rather than to surface vessels.

Mr. R. D. OLDHAM: I have read Mr. Harding King's paper and listened to his abstract with great interest. I can confirm all the facts recorded from my own observations in localities where sandhills were encroaching on stony ground. In districts which have been completely covered with sand the earlier stages are not easily distinguished. On one point only must I differ from the author, with regard to the eddy under the lee of the crest; I have frequently observed it as a distinct whirl with a horizontal axis, but always of comparatively small dimensions. So far as my observations go, the extreme dimensions must be put at about 20 feet in diameter, but the usual size is much smaller. In the earlier stages of formation this eddy has some influence on the shape of the sandhill, and the ground immediately to leeward of the hillock can be seen

to be swept clear of fine sand by the reverse current of the air ; after the sand-hill has reached a height of 10 or 15 feet the influence of the eddy becomes unimportant, and the reverse current no longer reaches the ground-level in sufficient force to move the sand, with the result that the limit of the sandhill is much less sharply defined. With regard to the origin of the long narrow lines of sandhills, I am in agreement with the chairman, in doubting whether they can be solely due to southerly drift of the sands, from a northern source of origin, before the prevailing wind. The explanation does not seem to account for the comparative and uniform narrowness of the sand-belts, and I cannot help feeling that the true explanation will ultimately be found in some other direction. These points of difference do not, however, detract from the interest of the body of observations which the author has put on record.

Mr. GODFREY SYKES : I have had the pleasure of observing the sand-belt to which Mr. Harding King has referred in his paper in two places. I have seen it where he has studied it, that is to say, where the railway crosses it, and again much further north where it is crossed by the camel route from the Bahariya oasis to the Nile at Miniya. There it is a broader, more massive belt, its main characteristics being rather sharply pointed hills interspersed by pits. I have also had an opportunity of examining the next great sand-mass to the westward, that is the sand which extends northward from the Dakhla oasis at its north-west corner towards Farafra. Here the conditions of distribution are quite different ; one travels along a wind-swept valley between two lines of dunes, the floor being perfectly clear of sand and the edges of the dune belts well defined. I have climbed and examined the dunes on both sides quite minutely, and impressions I had received in other sand regions were confirmed, namely, that with sand of any given character certain optimum conditions may exist, wherein a balance is struck between wind and sand, with the result that defined sand-belts or orderly lines of dunes are produced. Excess of wind in relation to the available supply of sand will produce isolated patches or banks, and excess of material in relation to wind will produce sand-fields or ill-defined areas of deposition. I think that possibly one of the explanations for the defined lines may be the comparative amount of friction between the wind-packed surface as other sand blows over it and the surface of the bare ground. That is, the sand will move more freely over other sand than it will over the bare ground upon either side. Thus, given a strong wind from one general direction, the tendency, I think, will be to heap up the sand into a long and gradually extending line rather than spread it. Also, as the wind varies slightly and blows upon either quarter—speaking as a sailor would—it too tends to pile the sand back upon the wind-row rather than diffuse it.

Another point that occurs to me is this : I have observed sand in regions where the general wind conditions are about uniform, but in which two separate lines of sand will show quite different characteristics of arrangement. For instance, the dunes in one belt may have a general elliptical ground-plan with the major diameter up and down the wind ; while in another they assume more the form of the crescent moon ; that is, are much wider across the wind than up and down. This, I think, may be due to the fact that some sand will pack and be less easily moved by the wind than other, and so assume a different shape under its impelling force. The aptitude for packing possibly has something to do with the question of crusting. The crust, I am satisfied, may also in some cases be formed by dew, for south of the Bahariya oasis we observed a strong heavy dew one morning which was followed by a calm, sunny day. Before noon there was quite a perceptible crust on sand that had evidently been

moved not more than a day or so before. The formation of such a crust of course indicates the presence of calcareous or saline matter in the sand as well as merely the occurrence of dew. At all events it struck me at the time—although this is by the way—that here was a possible explanation of the ripple marks we see in sandstone, where layer after layer of ripples may have been fixed by dew without subsequent obliteration.

Another interesting fact about these lines of sand between Dakhla and Farafra is the occurrence of many of the hard patches, such as Mr. Harding King has referred to in his paper, in which the sand is quite firm to the foot. We found them generally upon the windward rather than the leeward side of the ridges. This is, in fact, somewhat similar to the conditions one sees so often in a tidal estuary. The caving pit that the author has described and figured in one of his slides I do not understand at all. It is mysterious how the sand should drop away in this manner. A possible explanation might be the decomposition of some buried organic matter.

As regards the eddy theory of the formation of dunes, I am disposed to agree with Mr. Harding King that the crescentic dune is formed in the main by the sand blowing up the weather side and dropping over the edge. I have tried the experiment sometimes of sticking a board horizontally into the face of a dune—the slipping face—and noticing what takes place. The sand simply piles on the upper side of the board and pours down over the edges as it accumulates. But as far as I have seen there is no trace of eddy action capable of whirling up the sand in advance, so that it could be redeposited on the slipping face. The sand as it blows up the weather side of the dune is more disposed to bounce than blow straight along, and the continual percussive action of this moving material probably tends to consolidate the surface so that the particles are not easily moved afterwards. The sand in motion seems to be lifted first from the extreme weather edge of the dune, and is blown partly up the slope and partly round the sides of the mass. Of course, as this feather-edge becomes blunted a corresponding layer will be peeled from the dune surface and dropped again in front.

Every man who has observed sand has of course been struck by the fact that the bulk of the sand is moved within a few inches of the ground. While I have never been able to take a satisfactory photograph of the sand actually falling over the edge and dropping on to the front face of a dune, I am satisfied in my own mind that the process as I have outlined it is substantially what takes place. Eddies no doubt play a great part in the formation of the horns, but I think less and less so towards the centre of the slipping face, and such eddies seem to move about a vertical rather than a horizontal axis so far as I have observed them.

Dr. J. W. EVANS: My experience of these crescentic sand-dunes was mainly in Peru, but I had not the same opportunities as the author of studying their mode of formation. Like most other speakers, I am much perplexed by the long lines of sand-dunes which have been described. I cannot understand why the wind should be so very persistent in one exact direction, and even if it were, how it should form these long lines. Another difficulty is that the direction of the lines of sand-dunes is north-north-west. One would not expect in the northern hemisphere to have persistent winds from that quarter. I am not prepared to speak positively on the question of the part eddies play in the formation of sand-dunes. My inclination has been rather against the importance of their action, because in the deposits formed by wind-action which I have been able to study in Kathiawar there is distinct and regular

stratification. One would not have thought this would have resulted from the interplay of eddies and gravitation. It is possible, however, that the stratification may be closely related to the formation from time to time of a crust on sand-dunes as described by the author. I believe with Walther that it is due to the presence of moisture. The only question is, what is the source of this moisture? There is, of course, the dew; but the dew is, according to Walther, at any rate, an exceptional phenomenon in the desert. It is probable, however, that the material that cements the sand together includes deliquescent salts. The author has given two accounts of its composition. According to one of these it was carbonate of lime, which was to be expected, considering that the sand is stated to have come from a limestone plateau. In the second place we are told that there were salts soluble in water, and about one-third of this is given as common salt, sodium chloride. What was the rest? Perhaps the author could give us information on this point. With the sodium chloride was probably a certain amount of more deliquescent salts, such as exist in sea-water, for I believe that the salt found in the desert is probably in most cases derived from the sea by wind-action in the manner suggested by Sir Thomas Holland. If this deliquescent material were present moisture would condense on the surface of the sand, even when there would be no dew under normal conditions. I would suggest that these salts cause condensation of moisture and a caking of the sand, this whenever the dew-point is approached, even though not actually reached, and then, with the help of the chloride of lime, a crust will be formed. We can now understand the development of the stratification. Whenever there is a pause in the formation of the dune a crust is formed, if conditions are favourable, by the condensation of moisture at night and its evaporation the following day. If loose material accumulates above this crust, no matter how, it too will sooner or later be covered with a crust; and if these successive crusts are approximately parallel a well-marked stratification will result. In conclusion, I must congratulate the author on the record he has given us of his work, which ought to be fruitful in valuable results.

Dr. J. S. OWENS: With reference to the eddy, the presence of which Mr. King attempted to investigate by means of a smoke-rocket: it seems to me that the smoke was emitted on the wrong side of the wall to bring out the existence of the eddy. If it had been emitted on the lee of the wall he might have seen the air revolving; whereas the smoke carried over from windward would only pass away in the direction of the air-current. In other words, the eddy is not formed from the air which goes over the top of the wall; but that which, on the lee of the wall, is set revolving by the friction of the current going over. I have been more interested in the physical aspect, perhaps, than the geographical, as I have not had the opportunity of seeing these particular dunes, and it occurs to me that the physical causes for the formation of the crescent dune are most complicated and very interesting. I do not know whether it is possible to see what they are *a priori*, but there are one or two considerations which bear on this. Sand can only be carried either in the air-current or rolling along the ground; in the former case the air which strikes the windward slope of a dune has an increasing velocity, as it is squeezed into a narrower section. On the other hand, as it flows down the leeward slope the velocity is falling off. That must have an effect on the degree of erosion produced at any particular part of the dune, since the erosive power would go up with the velocity. Then again, on the windward slope you have gravity opposing the flow of sand up the dune, while you have it helping down the leeward side, the tendency being towards a curve of face in which at any

point gravity acting down the slope balances the effect of the wind acting up. The same thing applies, I think, to a movement of sand by rolling, although the conditions which bring it about are slightly different, because as the wind blows up the windward face of the dune there is a certain amount of deflection sideways, so that there is a tendency for the mean velocity of the current along centre line to be somewhat reduced as it goes down the dune. I think there is therefore a tendency to increased erosion on the windward side and increased deposition on the leeward side. I am aware it is not very clear how these things affect the shape, but I feel that one cause of the formation of the crescent dune is to be found in a retardation of the movement of the leeward as against the movement of the windward slope; that is, the windward tends to overtake the leeward, and so you get a pouring down of the sand at the angle of repose. What causes the retardation of the windward slope is not very easy to see, but no doubt the height of the dune affects it. Is it possible that the crescent dune is really what might be called a starved whale-back? That is, that the crescent represents a whale-back dune in which there is not sufficient sand to completely fill the empty part lying between the horns. It appears that the crescent is always a development of the whale-back according to Mr. King, and I also gather that sometimes the crescent again degenerates into a whale-back; it seems therefore that they may be really the same thing, the crescent being an incomplete whale-back.

Another point I would refer to is the explanation Mr. King gives of the regular spacing of the dunes, that is, like a series of waves. I have tried to follow his explanation in the paper, and cannot quite agree with it. I am rather disposed to the view that the regular spacing is due to some periodic undulating movement in the air rather than a function of the rate of growth of the dunes, which, I understand, is Mr. King's idea. With reference to the crust and the pit found on breaking it, given the formation of the crust the explanation of the pit seems easy, because it is well known that granular materials can be packed in many ways, and in only one do they occupy the least possible bulk. It is possible the dunes as originally deposited do not occupy the least volume. Any vibration would cause the sand to settle down and leave a space under the crust. In conclusion, I wish to thank Mr. Harding King for his excellent paper.

(*Note added after the discussion.*)

Since the discussion on Mr. King's paper some points relative to the crescent formation have occurred to me.

1. In dunes which are growing and receiving sand in suspension from outside, the height must affect the rate of travel, as the supply of sand does not increase with the height, which governs the volume to be filled on the lee per unit of advance.

2. In dunes which are not growing or receiving sand from outside, but where the windward slope is the source of supply for building up the lee, it would seem that the height cannot affect rate of travel, since both area of source and volume to be filled vary directly as height.

3. The sideward deflection of the air-currents by the dune-wall tend to cause a greater flow of sand over the crest near the sides than near centre line.

4. Except along centre line of dune the steepest gradient is everywhere towards the sides; thus gravity tends to draw the sand sideways away from the centre line.

All these make for a more rapid movement of the sides than centre.

Mr. HINKS: May I join others in congratulating Mr. Harding King on the interest of the results that he has given us in this paper. It is especially useful to have such clear reasons for discarding the facile but evidently superficial notion that one can gain anything of value by likening the orderly succession of the desert dunes to the waves of the sea. We can see from the descriptions that Mr. Harding King has given us in this and preceding papers that the most perfectly characteristic dunes are those in which the analogy to the wave is least. Firstly, the medium is discontinuous, the best dunes having clean sandless desert round about them, yet marching forward over it in their orderly procession. Secondly, the march of the dunes is unlike that of waves in that it continues in a long line without spreading. It seems to me that the prevailing wind cannot have such singleness of direction that it can preserve a dune-belt in its original narrowness for hundreds of miles, and that we must perhaps recognize with Mr. Godfrey Sykes a shepherding effect of a wind a point or two off the normal. Would it not affect more strongly the unsheltered dunes to windward and drive them in on the main procession? Such a conservative action seems natural and effective; but it is as unlike any effect of wind on waves as can well be. Thirdly, the advancing dune has a concave front; fourthly, the smaller dunes move faster than the big ones; and fifthly, the dune advances by its material being blown up the windward slope, part to be blown away and part to slide down the leeward face when its inclination exceeds the angle of rest. Here are five good reasons for saying that there is nothing in the behaviour of the dune which has any analogy with wave motion, and I think that we may take that analogy as exploded. There remains a good deal to learn on the details, and I should like to know more of the action which on a reversal of the wind first produces a heap or ridge at the crest of the dune. When the great air channels at the National Physical Laboratory are no longer so urgently wanted for other inquiries, one may hope that it may be possible to make some experiments on this point, with facilities in the perfect control of wind direction and velocity not to be found in the desert. We may then learn more of the really important art of killing dunes. In the desert of Atacama, Mr. Barclay tells us, they do it by throwing a barrowload of gravel on the dune, which then withers away. I have always felt that we should like to know more of the way in which this simple cure works, and whether it is equally effective in other countries.

Mr. REEVES: It seems to me that the value of that kind of work depends, to a great extent, on the accuracy with which the dunes are surveyed and mapped. If a reliable survey could be made and repeated after a certain number of years the importance of the results would doubtless be considerably increased.

I would venture to suggest that on another expedition Mr. Harding King should at any rate use some more accurate instrument than an army service clinometer for the measurement of the vertical angles. There is, I believe, considerable difficulty in using a theodolite for the purpose, as the legs of the tripod are continually sinking into the ground, and so the level bubble is constantly changing its position; but this might perhaps be overcome by reading the level at the instant the observation is made, which could be done by means of a small reflector placed at a suitable angle above the bubble. Even an Abney level would, I think, be better than the ordinary service clinometer, especially if it could be placed on a rod or some other support.

As to the eddies to which reference has been made by the author and

other speakers, it is clear that the direction taken by any air currents caused by winds striking a dune must depend greatly upon the angle of slope the dune presents to the wind. Under suitable circumstances it seems to me reasonable that eddies should be formed, especially on the windward side, but whether they would have the effect of changing the face of the dune, as Dr. Vaughan Cornish supposes, is another matter. I should like to say a few words in connection with Mr. Harding King's smoke experiments, for I hardly think the result he obtained is conclusive. A house I lived in once had a roof with a long gable facing west, and about the centre of the wall was a chimney which only rose to something like half the height of the gable. Whenever the wind was in the west it struck the gable, with the result that eddies round a more or less horizontal axis were formed, and all the smoke and flame came out into the room, which in consequence had to be shut up. This, at any rate, was the architect's explanation of the difficulty, and the only way to overcome it was to alter the shape of the roof near the chimney, and build the latter much higher than the gable.

Mr. W. J. HARDING KING: Many points in the discussion turned on the question of the eddy under the lee of an obstruction. I would like to remind you that it is not only necessary to have an eddy in this case, but you must, I think, have an eddy which will move the sand for it to have any effect upon the shaping of the dunes. The first evidence of this is rippling. But has anybody here seen reverse rippling in the troughs of big dunes with normal wind? Personally I never have. With regard to the persistence of the N.N.W. wind, Mr. Beadnell made a number of observations on the wind in this district, and found that in five days out of six when the wind had sufficient force to move the sand it invariably blew from, approximately, N.N.W. He found by cutting open one of these crescentic dunes that it was stratified in layers parallel to the flat face on the lee side. With regard to the question of moisture, though it is not at all uncommon in the Algerian Sahara, I never remember to have encountered dew in the Libyan desert, but of course you do occasionally get rain there; in fact, there are one or two cases on record where they have had such heavy rain that the mud houses in the oases have fallen down afterwards. My view of the flat face on the top of a dune is, that if you have a reverse wind blowing up the lee face, the first effect that it has is to form a small mound with a rounded top on the summit of the lee face, and as the top of this gets pushed down wind, a flat face forms on the lee side of this small mound as a result of the shortening of its lee curve, and you then get the form shown in Fig. 5 (b), which I ought perhaps to have shown as the third, instead of the second, stage. Then there is the question as to whether the crescent is a starved whale-back. I do not think that is so, because a whale-back increases in size as it develops into a crescent dune.

Dr. J. S. OWENS: Are the whale-backs ever as high as the crescents?

Mr. HARDING KING: No, I have never seen a high whale-back; it is nearly always a low dune, as far as I have seen; they are not a very common form in that particular part. Again as to the eddy. It was suggested that an eddy is never 20 feet in diameter, and that consequently I should not have felt the wind under the lee of the dune when I camped there. The height of that particular dune was 23 feet.

Dr. CORNISH: I gave that as a very extreme limit. Those I have seen have been about 6 or 8 feet in height. One could see the sand circling round. The wind was just under the lee of the dune in the early stages; strong enough to sweep the ground close underneath it. As soon as the dune

rises to some height it is not affected; it is only in the smaller ones it has any effect.

Mr. HARDING KING: The Chairman said that the wind on coming through a gorge expands on the other side, and that consequently the belt would widen here. Surely it is only for a very limited distance. I think there might be local expansion from this cause, but I believe that the explanation given by Mr. Hinks of the narrowness of these belts is the correct one. For suppose that the line of dunes runs from north to south, an abnormal wind, say from the north-west, will blow some of the sand-grains off the belt on to the desert to the south-east of it, and will move the belt as a whole slightly in the same direction. But when the wind blows from another abnormal—say north-easterly—quarter, some of the grains blown off the dunes by the north-west wind will be carried in again on to the belt, be caught in the rippling, and will again become part of it—the belt in this way tending to preserve its bulk, the dunes themselves composing the belt will at the same time move back again slightly in a south-westerly direction—the total effect of these two winds on the dunes being to cause them to move in the direction of the diagonal of a parallelogram of forces, whose sides are represented by the two abnormal winds. I could not quite understand Dr. Cornish's point. Does he say that a stationary crescent dune is a wave? Surely there is no wave motion at all.

Dr. CORNISH: I have dealt with it somewhat fully in the books and papers and shown where the utility of the true analogy of waves runs out, that is to say, when you get a solitary mound, the utility of the analogy almost comes to an end. When you are dealing with things in sequences then it becomes most useful, because the word "waves" is in itself generally a noun of multitude.

Mr. HARDING KING: You mean you must have a sequence.

Dr. CORNISH: It is difficult to say "must"; it is possible to have such a thing as a solitary wave, but the greater part of wave phenomena have to do, undoubtedly, with depending sequences.

Mr. HARDING KING: Quite. The Chairman raised a question as to the crusting, and asked whether that was renewed with the change in the dune. So far as I saw, when the top of a dune was turned, the crust that was previously there was immediately restored when the dune went back to its original shape.

The CHAIRMAN: A fresh surface of sand gets crusted in turn?

Mr. HARDING KING: Almost immediately.

The CHAIRMAN: And that does not prevent the movement of the dune.

Mr. HARDING KING: Yes, I think it has a very slightly retarding effect, but not a very appreciable one; not at least in normal dunes.

The CHAIRMAN: I am sure every one present wishes to convey a very hearty vote of thanks to Mr. Harding King for this most interesting abstract of his paper, and to those who have taken part in the discussion for the way in which they have really thrown light upon the whole question.

CLIMATE OF NORTH-WEST AFRICA

Mission Scientifique au Soudan, 1ème fascicule.— H. Hubert. Paris: Emile Larose. 1916. Pp. 320. *Maps and Illustrations.* 12*s.* 6*d.*

MONSIEUR H. HUBERT had previously been entrusted with a scientific expedition in Dahomey which was mainly concerned with the geological structure of the country. His report on this has already appeared. In

1908 he was commissioned to study in the field the geology and the mineral resources of a tract of country lying to the south of the upper Niger, to the north-west of the Gold Coast Colony, and to the north-east of French Guinea. His geological results are to be published later; but in order to deal satisfactorily with the geography of this region he has first of all discussed in this volume the climatic conditions. Twenty-two months' work in the field and several years' acquaintance with Western Africa have enabled him to produce a very useful and interesting memoir on the meteorology of the region lying to the west of Nigeria, and especially of that portion between lat. 10° and 15° N. The importance of meteorological information in colonies under development, when this is properly utilized, is strongly insisted upon, and certain agricultural districts of the upper Niger are specified, where the population is already as dense as the native method of cultivation can provide for. Here a premature or retarded rise of the river-flood, and the variations in its height, are as important as in the Nile valley, so that any additions to our knowledge which may aid in forecasting the character of the coming flood are of the greatest importance.

M. Hubert discusses the data from forty-seven stations, some of which have been in operation for fifteen years, but others for much shorter periods. A few stations outside the French colonial territories have been utilized to provide one year's observation only (p. 35), but considerably longer periods are available for them; Lagos, for instance, has rainfall records dating from 1886, Gambaga from 1899, etc. The temperature in various parts of West Africa, and in the different months of the year, is discussed at length, and isotherms are drawn for each month, both for the observed values and again for the values when reduced to sea-level, since some nineteen of the stations are at altitudes of more than 1000 feet above sea-level, and one of them, Labe in French Guinea, is about 4000 feet above it.

Local conditions which may affect the temperature of a place are fully discussed, and some useful information on the degree to which different rocks are heated by the sun's rays is included. But the two main factors which determine the yearly march of temperature over this part of Africa are the position of the sun and the northward advance of the monsoon rains in the early summer and their retreat before autumn. The author selects the mean monthly extremes (*i.e.* the highest and the lowest temperatures observed in each month for the years available), as giving the best representation of the climate for his purpose, and for questions bearing on human settlement and on agriculture these elements have much in their favour.

The monthly isothermal charts of the mean monthly maxima and mean monthly minima are discussed at great length, and explanations are sought for the occasional anomalies which appear. The whole provides a careful and very detailed discussion of the thermal conditions of the country, though the data seem in some cases to be somewhat insufficient to support adequately the deductions made.

Finally, the author distinguishes five climatic districts, of which three, the Sahelian, the Sudanian, and the Libero-Dahomean, form three parallel belts of country from Timbuktu to the sea. In the first of these the lowest temperatures occur in the winter, and the highest in the early summer before the rains, which are not heavy and only last about three months. The Libero-Dahomean district includes the southern coast and the country immediately north of it. It is characterized by a small range of temperature, and by a large rainfall with two well-marked maxima, separated by a minimum about

mid-summer. Intermediate both in position and character between these is the Sudanian type, where the lowest temperatures occur about August in the rainy season, which is long and heavy.

Besides these three climatic districts there are two special ones: the sub-Canarian, which includes the coast of Senegal, and the Futanian, which is restricted to the high Futa plateau of French Guinea.

Passing to the discussion of the winds, we miss any consideration of the seasonal distribution of pressure over North-Western Africa, on which the air-currents depend. Stations offering reliable barometric observations are not numerous, and the altitude of some of them above sea-level is not known with accuracy; but the subject has been discussed a good deal in recent years, and the general character of pressure distribution is known.

Besides the daily alternation of land and sea breezes which is so strongly developed on this coast, the author groups the air-currents of this region into the trade-winds on the coast of Senegal, the Harmattan or east and north-east winds blowing from the interior, and south and south-westerly monsoon winds which commence on the coast in March, reach Timbuktu in July and August, and withdraw to the coast by the end of October.

Certain facts quoted by the author are of considerable interest, such as the presence of an easterly wind at the hill-station of Mali (about 5000 feet) throughout the year, and the westward movement of the alto-cumulus clouds at heights of about 8000 or 10,000 feet, which point to a steady circulation above the warm rain-bringing currents of the south-western monsoon. On the coast of Senegal, too, the northerly trade-wind has been often reported as prevailing above the south-west winds of the rainy season, and in fact both this trade-wind and the Harmattan are air-currents circulating round the high-pressure system which extends from the Azores over North Africa, shifting its position slightly in the course of the year. This does not appear in the work before us, as pressure distribution is not discussed.

Rainfall is discussed at length, and monthly rainfall maps are given, but it is not stated on how many years the monthly mean values in Table V. (p. 184) and the maps are based. The values therein given differ in some cases appreciably from other recent work on this subject (C. E. P. Brooks, *Q. J. R. Meteor. Soc.*, vol. 42, 1916, p. 85).

As much of the rain that is experienced falls in connection with the heavy thunderstorms of the rainy season, these phenomena are discussed at length, and interesting descriptions of particular storms observed by the author are given. From May to September they occur very frequently, and at some stations almost daily. As has been frequently recorded, these storms move usually from the south-east, and the normal south-westerly wind drops as the storm approaches, being replaced immediately by a strong or even violent easterly wind with heavy rain. The author recognizes that the upper easterly air-current plays an important part in these storms, which are air-whirls carried along by it. In them the moist south-westerly air-current is carried up and dynamically cooled by expansion, causing the heavy precipitation which is their most marked feature.

Heavy squalls without rain, the "habub" of the Eastern Sudan, are mentioned as being not uncommon in the early part of the rainy season or at its close. The author attributes more of the rainfall to the cooling of masses of saturated air than most meteorologists would be disposed to admit, and while recognizing the action of convection currents in carrying up air masses into regions of lower pressure, he hardly allows enough for the formation of

cloud, and even condensation of moisture into rain, through the agency of turbulent air motion set up by the movement of the south-westerly air-current over the irregular surface of the country.

Some discussion of directions in which his work has amended or extended that of others who had dealt with the meteorology of this region might have been expected; but perhaps this will be supplied later, as the discussion of evaporation has been postponed to a future volume of his report.

H. G. LYONS.

REVIEWS

EUROPE

Trentino e Trieste.— Attilio Brunialti. Torino: Unione Tip.-Ed. Torinese. 1916. 50*s*.

SIGNOR BRUNIALTI has set himself the task of providing his countrymen with a comprehensive account of all the territory which might be claimed on geographical or strategic grounds as belonging to Italia Irredenta. He includes in his survey the whole of the Austrian possessions which lie on the Italian side of the Alpine watershed. He divides his subject into the Trentino, the Alto Adige with the Ampezzano, Eastern Friule, Trieste and the Karst region, Istria, Fiume with the Quarnaro, and lastly Dalmatia. In each section he discusses the boundaries, the mountains and valleys, the river systems, the climate, flora and fauna, the inhabitants, the history, the economic conditions and the sea-coasts, besides giving us a gazetteer which has something to say of even the larger villages. The book is appropriately illustrated and contains a number of good maps and plans.

It is on the strictly geographical side that Signor Brunialti appears at his best. The superiority of his method over that of the author of the "Oesterreichisch-ungarische Monarchie in Wort und Bild" is obvious. We have the material systematically tabulated instead of being obliged to collect it from a general account of the country written largely with an eye to the picturesque. The information is carefully selected and well proportioned. The chapter on the Trieste Karst, for instance, is thoroughly adequate, and in attempting to trace the courses of the more important underground rivers, notably of the Reka or Tinavo, enters into some detail. In describing the mountains the author never fails to give an account of the history of mountaineering in each region, recording the first ascents of the principal peaks and mentioning the huts that have been erected by the Alpine clubs of different nationalities. Limits of space prevent him from giving more than a summary of the history, anthropology and the economic conditions of the various provinces. Agriculture perhaps fares better, and the important roads and railways are duly mentioned. On page 401 we note that the rainfall at Monfalcone is given as 9950 mm. Surely this is a misprint for 1950. It is a pity that Sig. Brunialti has not seen his way to do more than mention the names of his authorities for each section in the text. The list is invariably long, and might well have been replaced by a systematic bibliography, which would have greatly increased the usefulness of his book.

We do not propose to discuss the claims of Italian, Austrian and Slav to the disputed territories. But even German writers do not attempt to defend a frontier line which violates all principles of common sense and might in many places have been designed by a commission of expert smugglers. Our author

devotes much space to a detailed description of both the international boundary and the Alpine watershed which he would substitute for it, appealing to the impartial science of geography to justify his claims. Yet even geography has been tampered with for political purposes by a certain class of German writers. "As Austria carried the Tirol into the Italian valley of the Adige, so she brought Carinthia into the Fella valley, and Carniola into the Italian valley of the Vipacco." The strategic advantages of the watershed as a frontier are obvious, but unfortunately it would play havoc with the legitimate claims of the Slavs in all directions, and we do not imagine that many Italians would expect to see the tricolour wave over more than a moderate extent of the territory with which this useful and interesting, if bulky, book is concerned. The publishers would have earned the gratitude of its less muscular readers if they had divided it into two volumes. L. C. M.

ASIA

Japan Day by Day (1877-1883).— Edward S. Morse. Boston and New York: Houghton Mifflin Co. 1917. 2 vols. 8vo. *With 777 sketches by the author. Price* $8.

Prof. E. S. Morse has, in his eightieth year, published a diary which carries us back to Japan in 1877, and which evokes from me gratitude and rhapsody such as one gives to the Diaries of Pepys or Evelyn, the narrative of Marco Polo, or the precious collection of Hakluyt. We cannot classify Morse, much less criticize him after the manner of an orthodox review. We read him, we thank God that he wrote, we learn and laugh at every page, and finally we place him reverently on the shelf beside Johnson's 'Journey to the Western Islands of Scotland' and Borrow's 'Bible in Spain.'

Morse went to Japan forty years ago in search of Brachiopods. He remained as Professor at the Tokio University and learned something from every step he took. He interrogated with the earnestness of a Darwin and recorded with the gaiety and elegance of Herodotus. True he was not a geographer by calling, but as geography impinges upon every manifestation of Man on Earth, so Morse appeals to us from the many-sidedness of his attainments and mental vision. To him science includes all things that serve the needs of man, and our professor at the Tokyo University has recorded in two octavo volumes an infinite amount of practical observation interesting to the zoologist, the archæologist, the ærtist, the architect, the cabinet-maker, the political economist; indeed, I have not room to enumerate the themes which his keen and honest pen has illumined. No other, not even the late Lord Redesdale, has done more to explain the old Japan to us, and these two notable travellers resemble one another in each possessing indefatigable muscles, irrepressible good humour, and infinite capacity for friendship. Morse fell into the happiest of social relations from the start; he not only set to work at the language, but never moved without a suite of devoted students able and enthusiastically willing to explain every minute detail to his cross-questioning note-book. Moreover, Morse was clever with pencil no less than pen, and these volumes include no less than 777 thumb-nail sketches done under every conceivable condition, in a rolling sampan, from a ricksha, in the crowded street, in a storm of snow or surreptitiously behind an umbrella. These are no pretty pictures, but technically accurate details on every conceivable Japanese matter from the carpentering on a fishing junk to the folding of a woman's kimono belt. Indeed the name encyclopædic is scarce an exaggeration when applied to this remarkable diary. Think of Wallace or Darwin one day letting themselves

by rope down into a black hole in the rocks for the purpose of reporting on the quality of scorpions and centipedes there at home; and on the next convulsing the official governor by practical jokes and laughable games! Not a problem of modern municipal administration or agricultural welfare but Morse touches and resolves it by Japanese example—and when we close the book it is with something of a sigh at the passing of an age of chivalry and the commencement of commercial commonplace. Japan has no warmer friend than Morse—no more frank and honest admirer. Not merely do we welcome his book as of interest to every student of Dai Nippon geographically; but to-day in particular we hail with pleasure the work of a Boston Anglo-American which cannot fail to assist in uniting for good the progressive forces of England, Japan, and the United States. POULTNEY BIGELOW.

Correction to Review in January 'Journal' (p. 42), "The Glaciers and Passes of the Karakoram."

We have much pleasure in responding to a request by Mrs. Bullock Workman, that we should correct a mistake which did grave injustice to her headman, the Wazir Abdul Karim. By a confusion which we greatly regret the faults of the "grain basha," who is three times mentioned as "headman" (pp. 154, 168, and 216), and whose name is indexed thus: "—— ——, misdeeds of, 128, 154–5, 168, 199, 200–3, 216," were in one sentence ascribed to the real headman, who served their expedition well and faithfully.

AFRICA

The Geology and Mineral Industry of South-West Africa.— Percy Albert Wagner. Union of South Africa, Mines Dept.: Geological Survey Memoir No. 7. Pretoria. *7s. 6d.*

"South-West Africa," in the days when it bore the prefix "German," was making extremely rapid progress as a mineral-raising region, being in particular the second diamond-producing area in the world. The present work is mainly a compilation from pre-war publications, and forms a very complete guide to the geology and mineral production of this large territory. The whole account is printed in duplicate in English and Dutch; it is illustrated by a large number of very fine photographic plates; a large geological map (scale 1 : 2,000,000) and several smaller maps and sections; and includes a full bibliography. A. M. D.

AMERICA

An Anthropogeographical Study of the Origin of the Eskimo Culture.— H. P. Steensby. Særtryk af *Meddelelser om Grønland*, 53. København: Bianco Lunos Bogtrykkeri. 1916.

Many different views have been held regarding the descent of the Eskimos, their culture and original home, all which are fully discussed in the opening chapter of this book, but no definite and unimpeachable conclusions have been arrived at. The author's method is to compare the forms of Eskimo culture on the different parts of the domain occupied by them with a view to determining which is the purest type. He uses the word "culture" in the sense of the German *Kultur*, and deals especially with the methods and implements employed in obtaining the necessaries of life, applying to this branch the term "economic culture." After full descriptions of Eskimo life in the northern regions of America, he concludes that the Eskimos were originally settled between the Barren Grounds and the prairie, where their culture was of the

Indian type, and that they migrated thence to the Central Eskimo area, from Coronation Gulf to the Melville Peninsula, where they developed the true Eskimo culture and whence they spread eastwards to Greenland, south-eastwards to Labrador, and westwards to Alaska. No doubt the culture of the Central Eskimos is distinct from that found in other parts, being peculiarly adapted to the severe climate and ice-bound waters of the Arctic archipelago and less exposed to foreign influence. Here only can the snow house be used as a dwelling throughout the winter, and the blubber lamp is accounted for by the scarcity of other fuels, even driftwood. But that all forms of Eskimo culture are derived from this source requires further proof. Why should not the Eskimos have migrated east, north and west from their primitive abode and modified their Indian culture according to the physical conditions of the region to which each section removed? Why, for instance, should not the Labradorian Eskimos have developed their kayak for open sea fishing directly from the Indian birch bark canoe, instead of from the kayak of the Central Eskimos?

The Eskimos of Alaska were naturally more exposed, at least in earlier times, to external influence. Umiaks, Mr. Steensby points out, were used by Asiatics of the North Pacific, and the bladder-dart and double paddle are of Asiatic origin. That the Greenlanders derived their umiak from the west is probable owing to the constant communication along the northern coasts, and in this connection it is to be noted that the central Eskimos know the name, though they have not the boat, which would be of no use to them. Mr. Steensby has written a very full and useful account of the question, though he has not been able to give a complete and perfectly satisfactory solution.

W. A. T.

GENERAL

Modern Whaling and Bear-hunting.— W. G. Burn Murdoch. London: Seeley, Service, & Co. 1917. *Illustrations.* 21*s. net.*

Mr. W. G. Burn Murdoch's 'Modern Whaling and Bear Hunting' might again have had added to its title 'Notes and Sketches by an Artist,' as was the case with his earlier 'From Edinburgh to the Antarctic.' Again we luxuriate in his bracing and easy artist's style, in which the traits of an exceptionally able sporting naturalist are combined with much that is solidly interesting to the geographer among many others. His account of whales and whaling strongly emphasizes the economic and national importance of the world's greatest mammals, beyond the sporting aspect of the subject, and he adds besides much that bears on aspects of physical geography in the many latitudes visited, especially in relation to sea and clouds and colour generally. The North and South Polar Regions he vividly describes in tone and tint and colour in a way quite unequalled by ordinary explorers with even highly developed photography. In this connection we may say at the outset that there is one cause for regret—that there are not many more of the excellent colour sketches, as well as more of the author's clever black and white work in lieu of some of the photographs. (As an instance of Mr. Burn Murdoch's effective way of conveying geographical instruction, we may refer to the pair of sketches on p. 255 and the accompanying statement: "This is the difference between Arctic and Antarctic: in one, Man and his vessels dominate the scene; in the other the great forces of Nature make Man and his works seem very small.") But we suppose such an addition to the cost of production has been impossible during the present prohibitive war conditions. Fortunately

the book was written before the war, and it is refreshing to read a story so full of interest without one note of the death-dealing war drone in it. It should be a book well fitted for the inmates of shell-shock hospitals and the like.

Economically there is much of geographical importance regarding whales and their products, which have been and are of vast importance to our colonial empire, and which have brought us at last to recognize the value of the large area within the Antarctic Regions recently officially attached to our Falkland Islands colony, out of which that colony is now annually reaping the profits of one of the most lucrative of industries. Mr. Burn Murdoch mentions that the gross annual profits from this whaling industry carried on in the Falkland Islands, South Georgia, the South Orkneys, South Shetlands, and even Graham Land amounted to £1,360,000 prior to the war, and we know that it greatly exceeds that amount at the present time; moreover, whale oil is actually one of the most important munition requisites for tempering guns and armour plates, and in this and other ways is of the utmost importance to our Allies and ourselves—a striking testimony to the importance of the Antarctic Regions, which require many more scientific expeditions to reveal their full utility.

Those at the head of the Food Controller's Department should read this book in order to learn that the whale affords one of the largest supplies of excellent meat in the world, and that from a British colony. "The best whale meat," says Mr. Burn Murdoch, "is better to eat and tastes better than the best beef; it is 'lighter' and more appetizing." The reviewer thoroughly endorses this statement, as he himself has lived largely dependent on whale meat—during many months as his chief food supply. A canning industry served by refrigerator meat vessels should at once be started at these Antarctic islands, and every encouragement should be given to the manufacture of margarine from whale fat. W. S. B.

The "Sunbeam" R.Y.S. Voyages and Experiences in many Waters.— Earl Brassey. London: John Murray. 1917. *Portraits and Illustrations.* 21*s. net.*

When this book was announced it was feared by many whose interest in the *Sunbeam* had been created or stimulated by the late Lady Brassey that it would be merely supplementary to 'A Voyage round the World,' and the ever-popular 'Voyage in the *Sunbeam*'; but the author has given us an entirely new book, throbbing with his own personality. There is nothing very new in fact, quotations are freely borrowed from Lady Brassey, and old pamphlets, speeches, and contributions to magazines are pressed into service; the newness lies in its fresh presentation, interesting reminiscences, and record of impressions. It is by no means a faultless book. We question the wisdom of departing so frequently from the chronological order and of having parts written by another hand; and his lordship performs a comprehensive task when he transfers Bressay Island from Shetland to become a "natural breakwater to the noble harbour of Kirkwall" (p. 43). Lord Brassey has always been a lover of the sea, and was elected a Fellow of the R.Y.S. as long ago as 1859. In his early days he sailed without serious purpose, but with the purchase of the *Sunbeam* he had the promotion of national and imperial interests constantly in view. He is proud of his fine ship, and tells how she sailed 1900 miles in a single week across the Atlantic, voyaged from Aden to Bombay in ten days, and on her last trip to India covered 1700 miles in seven and a half days. The accomplishment of Lord Brassey's life—

compared with which all other achievements are trivial—was the creation and organization of the Royal Naval Reserves, and although credit is due to Goschen and others for support in the House of Commons, the success of the Royal Naval Reserves is a lasting memorial to the patriotism, energy and skill of the then member for Hastings. The bitterest disappointment of his life was the abolition "on a trumpery question of uniform" of the Royal Naval Volunteers; and although this system was revived later the nation lost much by its eclipse. The author has been a keen observer, and we have the benefit of his observations in his judgment of men (p. 22), his description of local customs, and his graphic landscapes and seascapes (*passim*). With a few rapid strokes of the pen he pictures Hoy—"its red sandstone cliffs rising a thousand feet and presenting one of the most glorious sea fronts in the British Isles," the mountains of St. Anne, "their lower slopes richly clothed with vast forests of pine trees," and the banks of the St. Lawrence, the northern rugged and mountainous, the southern sloping gradually to the river. This lucid power of description is at its best in his pen pictures of Paphos, Ktima, Limasol, Larnaka, Nikosia, Kyrenia and Karavastasia—all drawn during his trip to Cyprus. He has many interesting things to say about cruises with Sir William Harcourt, Mr. Gladstone, and Lord Tennyson, and conversations with the Kaiser, the Queen of Greece, and Admiral von Tirpitz. We need only add that the book is carefully indexed, richly appendiced, and admirably illustrated. W. P.

GENERAL

Volcanic Studies in Many Lands, being reproductions of photographs taken by the Author.— **Tempest Anderson, M.D., D.Sc., F.G.S., F.R.G.S.** The text by **T. G. Bonney, Sc.D., LL.D., F.R.S.** Second Series. London: John Murray. 1917. 15*s. net.*

This second series of beautiful photographs illustrating volcanic phenomena is published fourteen years after the first series and four years after the death of the author, which took place in the course of his last journey among volcanic regions. The volcanoes illustrated include Vesuvius, Stromboli and Etna, the Soufrière and Mont Pelé in the West Indies, and others in Mexico, Guatemalia, New Zealand, the Pacific Islands, the Malay Archipelago, and the Philippines. There are altogether eighty-one photographs, including both general and detailed views. Among so many admirable plates it is not easy to select any for special mention, but perhaps as a beautiful picture of a distant volcanic cone, with a foregound of tropical vegetation, Santa Maria in Guatemala (Pl. 33) deserves first place, though the cone of Mayon in Luzon (Pl. 78) is a more perfect example of form. For impressiveness in their suggestion of the mighty forces at work we hesitate between the cliffs of Krakatau (Pl. 72), the night view into Kilauea (Pl. 55), and the meeting of liquid lava and sea at Savaii (Pl. 49). Among larger-scale views of volcanic detail we would specially mention the lava-cascade in Hawaii (Pl. 56), the bread-crust bomb (Pl. 31), and the Savaii pillow-lava (Pl. 50). There are impressive views of the interior of craters, such as Xinantecatl (Pl. 26); striking illustrations of the rapid denudation of volcanic accumulations, as on the Soufrière (Pl. 18); and tragic examples of destruction, both of vegetation (Pl. 15) and of human work, as at St. Pierre, Martinique (Pl. 23). It will thus be seen that practically every aspect of volcanic phenomena is illustrated, as well as every quarter of the globe.

The descriptive text is written by Prof. Bonney, and Mr. Yeld contributes a memoir of the author, whose portrait forms the frontispiece. The absence

of the author's own hand in preparation is seen in occasional uncertainties as to the exact site of a photograph ; but these are not enough to detract from the great value of the work, which is a memorial to the activity and thoroughness of Tempest Anderson, by whose death at the age of sixty-three that most valuable body of men, the scientific amateurs, lost a distinguished member.

A. M. D.

THE MONTHLY RECORD

EUROPE

The Etang de Berre.

THIS brackish lake or lagoon, the largest of the lagoons which fringe the Mediterranean coast of France on both sides of the Rhone delta, is the subject of a valuable monograph by A. Chevallier, issued as Fascicule IV. of Tome VII. of the *Annales de l'Institut Océanographique de Monaco* (1916). In part it is the outcome of personal researches principally concerned with the water of the lagoon and the deposits on its floor, but the author has made a thorough study of all the existing literature on the subject, and presents an interesting conspectus of our knowledge of the lagoon under all its aspects. The study is particularly timely by reason of the attention called to the Etang de Berre through the canal from Marseilles to the Rhone, now under construction, which in one part will skirt its southern shore and may bring about a revolution in its economic relations. Unlike the other lagoons on the same coast, the Etang de Berre was not formed by the deposition of a bar across the mouth of a former inlet of the sea, but is a feature in the general relief of the district, being surrounded by hills rising in places to a considerable height. It was known to the ancient geographers as the *Stagnum Mastromela*, from the town of the same name (destroyed by the Visigoths towards the end of the fifth century A.D.), of which some vestiges are still to be seen near the mouth of the Durançole. The site of the other old settlement in its vicinity, *Maritima Avaticorum*, is matter of dispute. Its wide expanse gives to the new-comer the impression of having reached the sea—an illusion heightened by the waves raised during the prevalence of the *mistral*—but it has never been frequented by shipping, though projects for its utilization as a harbour of refuge, or as a link in the desired waterway from Marseilles to the Rhone, have been mooted from quite early days, and had their partial fulfilment in the construction of the Canal Maritime, joining it with the sea by way of the smaller Etang de Caronte. It is at the exit of this canal from the lake that Martigues, the most important town on its shores, is placed. Only within the last twenty years has the scheme been taken up once more in its entirety, work on the great Marseilles–Rhone canal having been begun in 1908, and already made good progress. The completion is anticipated in about 1920. The origin of the lagoon is ascribed by the best authorities to the work of river erosion, all idea of a tectonic origin in a sinking of its floor being discarded. Opinions differ as to the particular river to which the erosion of the basin was due, M. Repelin thinking this to have been the Durance before its diversion to the Rhone through its own alluvial deposits, while M. Collot ascribes the work to the Arc, the largest of the existing feeders of the lake. At present there is a considerable amount of erosion on the shores exposed to the *mistral*, whilst elsewhere the water-surface is being somewhat diminished by deposition. The Arc has formed in the past an immense delta, and with its discharge of 700 cubic

metres per second in flood-time still brings down a very large quantity of sand and silt. The deposition of the finer matter is much accelerated by the influence of the brackish water. In proportion to its surface of 15,550 hectares the depth of the lake is but slight, the maximum being only about 10 metres, and the mean about 7. M. Chevallier gives particular attention to the composition of the bottom deposits—his own special subject of study—and discusses also the sources of water-supply, currents, changes of level, and the physical characters of the water. He describes the economic activities, which consist chiefly in the harvesting of the *Zostera* (grass-wrack), the fisheries, and in salt-making. The final section gives a full account of the Marseilles-Rhone canal, and considers the possibilities of industrial development on the shores of the lake as a result of its completion.

Population and Rainfall in Apulia.

Whilst the relationship between density of population and amount of rainfall is evident enough when major areas are considered, the most populous regions being those which are neither too dry like the Sahara nor too wet like the basins of the Congo or Amazon, such relationship in the case of the minor variations over smaller areas is usually hidden by various other factors, and it is therefore specially interesting that a case has been brought to light by Signore Colamonico in that southernmost part of Apulia forming the Terra d'Otranto, Province of Lecce (*Riv. Geogr. Italiana*, Ann. 24, maggio 1917). The cartographical resemblance between the distribution of people and of rain in this region of marked and protracted summer drought is very striking, the population and the rainfall varying in the same sense. The most thinly populated zone with less than 50 persons per sq. km. situated mostly along the western shore of the Lecce peninsula corresponds roughly with a precipitation of less than 550 mm. a year, and the most densely peopled area (with over 200 per sq. km.) with a rainfall of over 850 mm. Where so many factors influencing population must necessarily be present, one would not expect the correspondence between the two functions to be exact, but the author is no doubt right in claiming to show that rainfall is not a negligible factor in determining the local populousness of this corner of Italy. The expression of the result as a correlation-coefficient would have given extra precision, and inasmuch as the population-density areas are tabulated with respect to the iso-hyetal areas it seems that this might easily have been done.

Tree and Forest Limits in Northern Russia.

An interesting paper on the above subject appeared last year in the *Zeitschrift* of the Berlin Geographical Society (No. 4) from the pen of Dr. Richard Pohle, whose many journeys through the forests and tundras of Finland, Northern Russia, and North-West Siberia, coupled with a prolonged study of the literature on that part of the world, make him exceptionally qualified to discuss the relations between trees and their physical environment along the northern frontier of their habitat. He insists on the importance of distinguishing between the forest-line, *i.e.* the limit of continuous forests, and the tree-line, or line marking the extreme limit of the occurrence of individual trees (not really a continuous line at all). North of the zigzag line delimiting the area of continuous forest we find patches of forest ("forest-islands") separated by tracts of heath or tundra, the islands becoming less in extent and the trees more stunted, until at last they occur in quite small groups or merely as individuals. Both lines show a certain parallelism with the coast-line—an indication that their position is due to climatic factors originating in the

influence of the northern ocean. Dr. Pohle discusses the distribution and conditions of life of the principal trees represented, showing how their varying requirements in the matter of soil, light, soil- and air-moisture, or their liability to injury by frost and forest fires, account for their irregular distribution and varying power to maintain a successful fight against adverse conditions. The Scots pine is a light-loving tree, but makes small demands on soil fertility, and is thus able to maintain itself on the drier heath-lands. The Spruce—the most widely distributed tree in the region—is tolerant of shade, but is more particular as regards soil, and suffers from night-frosts, which render the shelter of other trees desirable. The Siberian larch—one of the finest trees of Northern Russia—requires abundance of light and a soil rich in mineral substances; its distribution is therefore irregular. The Siberian pine can flourish in swampy tracts with a cold sub-soil which would be prejudicial to other kinds. Facts of geological history as well as existing geographical conditions bring it about that the trees which reach furthest north are different in different areas. Thus, while the pine and birch are characteristic of the Finnish-Scandinavian borderlands (the birch especially of the extreme tree-line), the larch and alder take their place in the northern Ural and on the Western Siberian coast.

In the latter part of the paper Dr. Pohle gives careful attention to the causes of the progressive southward retreat both of the tree and forest lines, which some have thought to indicate a change of climate, and one observer has attributed merely to the adverse influence of peat formation. Dr. Pohle shows that some extraneous influence must be at work to favour the encroachment of one plant-formation on another, and finds it in the destructive work of man. Where conditions of tree-growth are in a state of unstable equilibrium, the felling of trees, by modifying the *local* climate (taken as the resultant of air, light, and soil conditions), may readily disturb that equilibrium, particularly in view of the rarity of seasons in which a crop of seed is produced. Although large areas of Northern Russia are almost uninhabited, the periodic movements of the Samoyedes and others along the borderland between forest and tundra entail much destruction of trees, which in course of centuries has an important cumulative effect. That the destruction must formerly have been even greater than now is manifest when we consider the much greater commercial activity once maintained in this region, as described in the narratives placed on record by Purchas in his 'Pilgrimes.'

AUSTRALASIA AND PACIFIC ISLANDS

Records of Pioneer Work in Australia.

In a recent annual address to the South Australian branch of the Royal Geographical Society of Australasia, the Hon. John Lewis took as his special subject the early settlement of South Australia, and by so doing has placed on record a good deal of interesting matter bearing on that settlement, and the pioneers who took part in it, together with data on the early introduction of stock and the export of wool and other produce. It may be recalled that South Australia owed its origin to an Act passed in 1834, by which all lands between 132° and 141° E. long. and between the Southern Ocean and 26° S. lat. were erected into a British colony; further enactments in 1842 and later years placing the government of the colony on a more durable footing, and regulating the sale of public lands to settlers. The first survey of the new colony was begun by Colonel Light—the founder of Adelaide—in 1837, and by 1841 a continuous area extending from Port Adelaide in the north to the shores of Encounter Bay in the south had either been surveyed into sections ready for

occupation, or was in course of survey ; whilst large tracts inland to the north and east had been specially surveyed for individual holders in blocks of 4000 acres and upwards. A map by Arrowsmith printed by order of the House of Commons in 1841, and showing the location of these surveys, is reproduced with Mr. Lewis's address, which also gives full lists of the early settlers, and miniature portraits of many of them. The statistics of the sheep, horses, and cattle in the colony in the early years of its existence show a remarkably rapid increase, the 28,000 sheep of 1838 having been raised to 360,000 in 1842 (largely by import from Tasmania and New South Wales), and to 480,000 in 1845.

Pioneer work of a more strictly geographical kind at the opposite extremity of Australia—the interior of the Cape York Peninsula—is summarized by Dr. R. Logan Jack in a paper read before the Australian Historical Society in 1915 and since printed in that Society's *Journal and Proceedings*, vol. 3. Although less known to the public than the great names of Australian exploration, the pioneers in the Cape York Peninsula needed qualities of determination and endurance fully equal to those displayed in any other part of Australia, and the record of their journeys is a striking tale of fights against almost insuperable natural difficulties (such as are presented by the steep and jungle-clad coast ranges), aggravated in many cases by the hostility of the natives. The most tragic story is that of Kennedy's expedition of 1848 (the start of which was witnessed as a young man by the future Prof. Huxley), from which, in spite of its unusually well-found equipment, only three survivors returned. The rough map accompanying the paper shows that nearly all the pioneers traversed the peninsula longitudinally, starting from the settled districts in the south, and the want of bases nearer at hand on the coast may account for much of the difficulty encountered. Trouble was often caused by ignorance of the river-system, the explorers being led astray by mistakes as to the identity of the streams struck by them. Following Kennedy came the brothers Jardine in 1864-65, Hann in 1872, Mulligan in 1873-75, and in 1879-80 Dr. Jack himself, who describes at some length his two trips for the geological examination of the interior. Of the above journeys Hann's was economically important for the resulting development of the Palmer river goldfield, whilst that of Mulligan (described by Dr. Jack as one of the most amiable men he has known) led to the opening of the Walsh Mineral District, with its mines of tin, silver, lead, copper, antimony, bismuth, wolfram, and molybdenite.

MATHEMATICAL GEOGRAPHY

Who originated Mercator's Projection?

Hitherto the chief point of discussion in the history of Mercator's projection has been the part played respectively by Mercator and Edward Wright in the introduction of this method of drawing maps. A new question has now been raised in Germany, which opens the possibility that the projection may have been known and in use for over half a century before its employment by Mercator for his great planisphere of 1569. The suggestion that this may have been the case has come from Prof. Drecker of Dorsten, who has an article on the subject in the *Annalen der Hydrographie* for June 1917, dealt with by Prof. E. Hammer in the October number of *Petermanns Mitteilungen*. The facts on which the suggestion is based are briefly these. The well-known map-maker of Nürnberg, Erhart Etzlaub—on whose labours much light has been thrown in recent years by the late Dr. A. Wolkenhauer (one of the many geographers who have fallen victims of the war)—was also

a "Kompastmacher," or maker of the small portable sun-dials with compass attached which went out in such numbers from Nürnberg and Augsburg in the sixteenth and seventeenth centuries. No such instrument from Etzlaub's hand has hitherto been known with certainty to exist. Prof. Drecker describes an instrument bearing the date 1513 which he has no hesitation in ascribing to Etzlaub, and he also prints the text of a MS. "Canon ad compastum Norenbergensem," or instruction for the use of just such an instrument, which internal evidence shows to have been certainly from Etzlaub's hand. This "canon" gives a sketch of the instrument (which is formed of a horizontal and a vertical limb capable of being folded together), and also shows that Etzlaub knew of the declination of the compass and its variation in different places. But the interesting point about the instrument of 1513 is the presence, on the outer side of the vertical limb, of a map embracing the portion of the Earth's surface from the Equator to the Arctic circle, and from the west coast of Africa to about 60° E. of that longitude, with the north at the bottom as in others of Etzlaub's maps, in which the parallels of latitude are spaced according to the principles of the Mercator projection. The map gives the names of 132 places, and was evidently intended to serve as an indicator of their latitudes, which are much more nearly correct than as given by many later map-makers. Its equatorial scale closely approximates to 1 : 100,000,000, from which its size may be deduced as just under 4 inches from equator to Arctic circle. Two pertinent questions are raised by Prof. Hammer, who in the first place asks for proof that the map is contemporaneous with the instrument. This seems to have been duly supplied by Prof. Drecker, who says that the script, etc., of the map quite agrees with that of the instrument (both using, *e.g.*, the antique form of the figure 4), and points to a second very similar instrument dated 1511 *on the map itself*, which uses precisely the same latitude scale as that on the instrument of 1513. The second question cannot yet be so satisfactorily answered. Why, Prof. Hammer asks, if the principle of Mercator's projection was already known to Etzlaub, was it never mentioned by any geographical writer in the interval between 1513 and 1569? The only explanation he can suggest is the known indifference to the advantages of the projection manifested in nautical circles even in Mercator's own time. In any case it remains to be proved that Etzlaub's scale of latitude was anything but an empirical approximation to the correct Mercator scale as worked out by Wright.

GENERAL

We are glad to note that Sir Aurel Stein has been awarded the Tchihatchef Prize of the Paris *Académie des Sciences* for his geographical work.

CORRESPONDENCE

Glacier streams in winter.

26 February 1918.

In my Address to the Geographical Section of the British Association in 1904 (printed in the *Alpine Journal*, vol. **22**; in the *Geographical Journal*, vol. **24**; and in the 'Annual Report of the Smithsonian Institution,' Washington, 1904) I pointed out that the streams issuing in winter from glaciers are not, as has been frequently alleged by scientific writers, the result of partial melting of the ice, but come from unfrozen sub-glacial springs. I was led to this conclusion by my own observations in winter in the Bernese Alps. From some glaciers

no water issued, from others a relatively slender and pure stream. Halfway up the Great Scheideck a copious fountain burst out through deep snow from the frozen ground, showing that such subterranean sources were still active and unfettered by frost.

Mr. Montagnier informs me that this observation is fully confirmed by M. Collet, Directeur du Service des Eaux of the Swiss Confederation, and the successor to M. Forel as the highest authority on limnology and kindred subjects. Mr. Montagnier writes: "M. Collet has found from his own experience that glaciers do not melt in cold winter weather, and that the streams issuing from them in that season come from springs. He thought he had been the first to hit on this fact, and was greatly surprised when I called his attention to your statement of it. M. Collet has had specimens of the water issuing from the lower Grindelwald Glacier in January and August carefully analyzed. The results prove beyond all doubt that the winter outflow is spring water with a large amount of mineral matter in solution, while the summer torrent consists mainly of the meltings of the ice, rendered turbid by the matter the glacier carries with it. M. Collet has in hand a paper on the subject in reply to a German savant who maintains that glacial streams in winter are a result of the internal heat of the earth."

So far as I am aware this observation continues to be ignored in most of the works and treatises that deal with glaciers. It is surely of sufficient importance to call for recognition by the writers of text-books.

DOUGLAS W. FRESHFIELD.

The "radigthe" of Symon Semeonis.

8 February 1918.

May I suggest to the author of the excellent paper on "Symon Semeonis" that the word "radigthe" or "radish" on page 80 of the *Journal* evidently refers to the horse-radish (raifort, rafano). May I also express my thanks for the pleasure which I am deriving from his most interesting contribution.

F. GLEADOW.

MEETINGS: ROYAL GEOGRAPHICAL SOCIETY: SESSION 1917–1918

Fourth Afternoon Meeting, 18 February 1918.—The Chairman presiding.

PAPER: A Transformation of the Magnetic Dip Chart. Mr. E. A. Reeves.

Seventh Evening Meeting, 25 February 1918.—The President in the Chair.

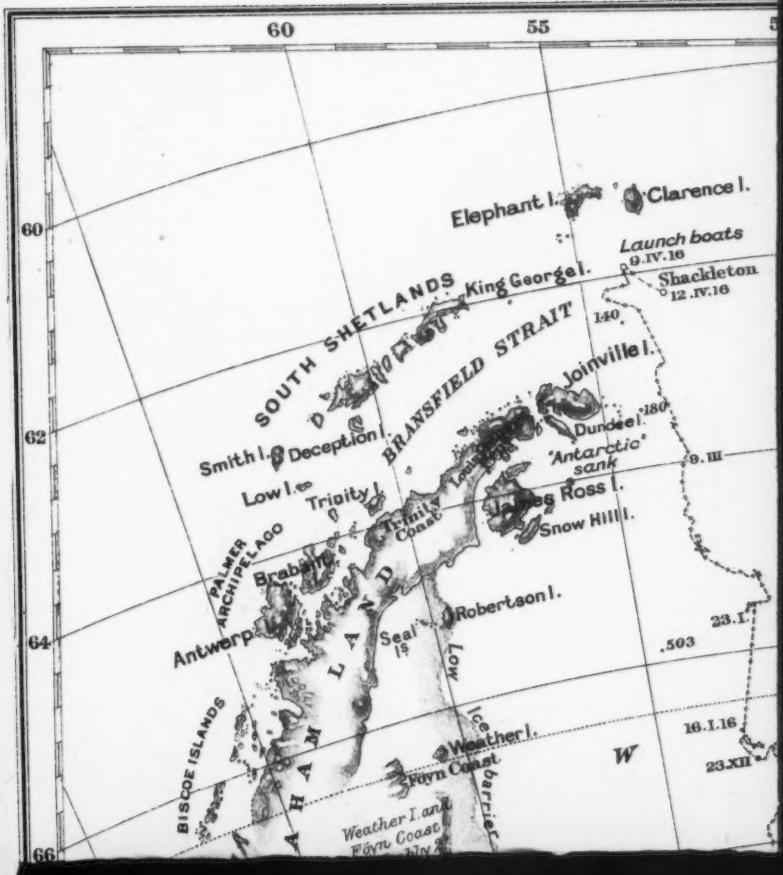
ELECTIONS.—Fred. Alexander Donnithorne; Captain Philip Hinckley, M.C., M.A.; Herbert Parrack, M.A.; Clement R. Stiles, F.R.S.S.

PAPER: Belgium and Germany in Central Africa. Comte Renaud de Briey.

Eighth Evening Meeting, 11 March 1918.—The President in the Chair.

ELECTIONS.—William Swan Arbuckle, F.R.C.I.; Charles Edward Cæsar; William Edgar Calner; Captain Edward Elgar Field; Captain Gordon Fisher, R.E.; Neil Alexander Mackinnon, F.R.C.I.; James F. Muirhead; Frederick John Nettlefold.

PAPER: My Second Year's Journey in Kansu. Mr. Reginald Farrer.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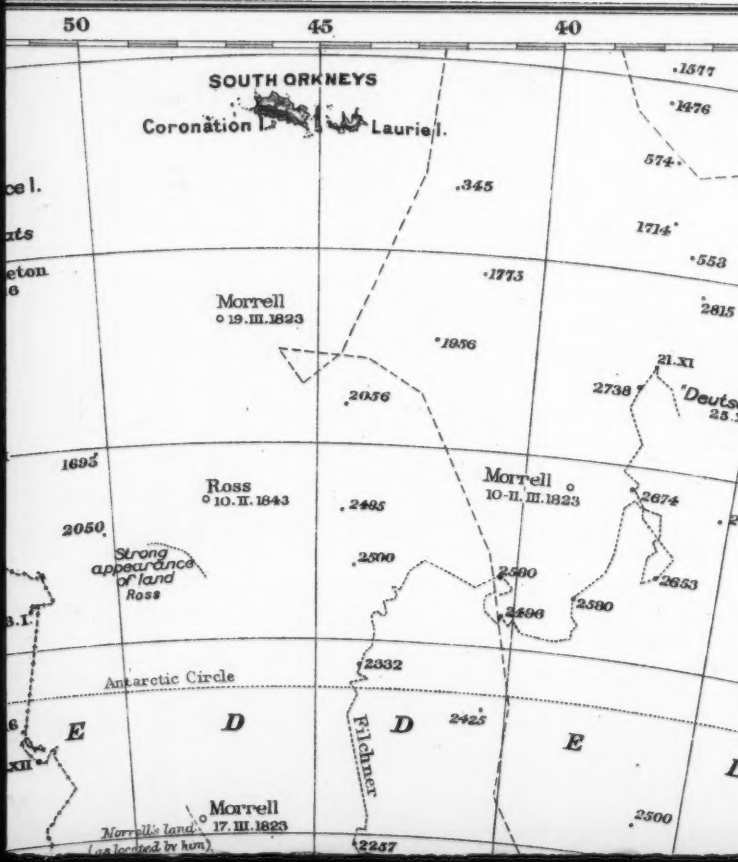
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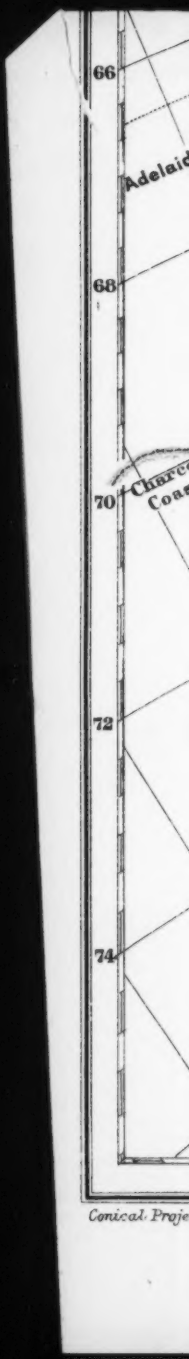
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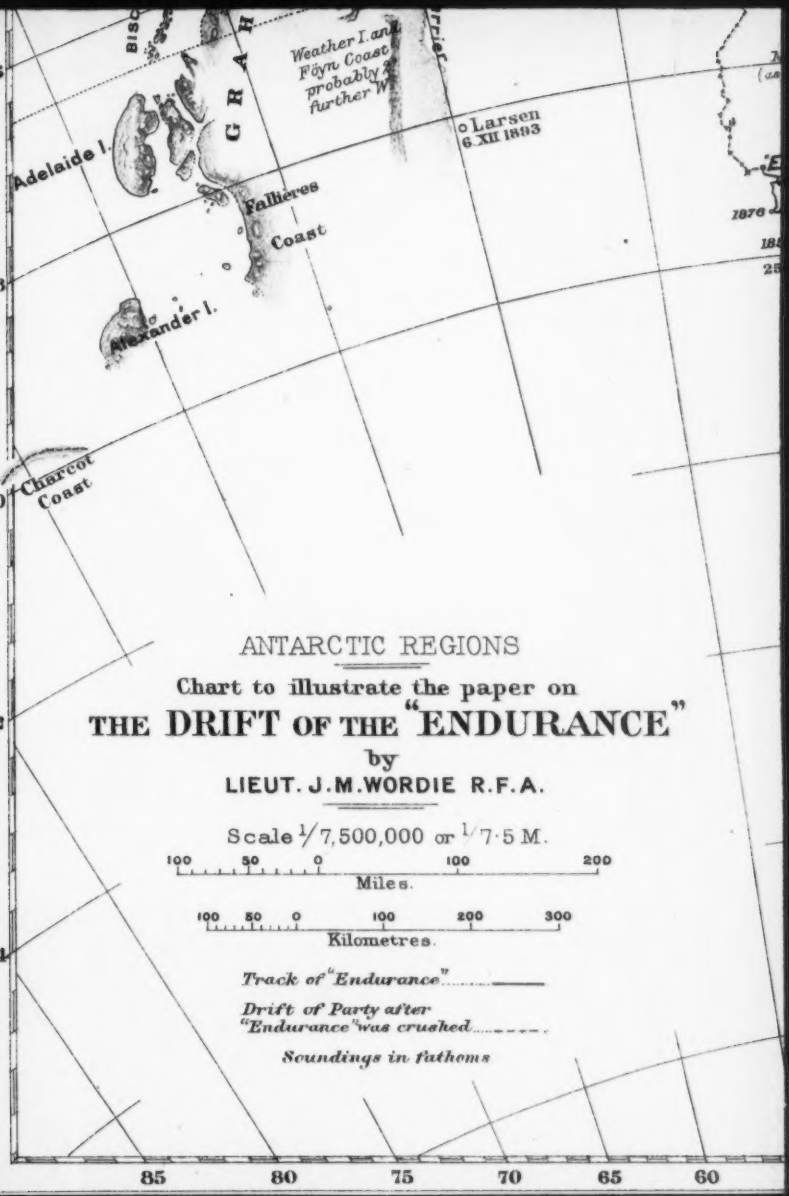


ANTARCTIC REGIONS

Chart to illustrate the paper on

THE DRIFT OF THE "ENDURANCE"

by

LIEUT. J. M. WORDIE R.F.A.

Scale 1/7,500,000 or 1/7·5 M.

100 50 0 100 200
Miles.

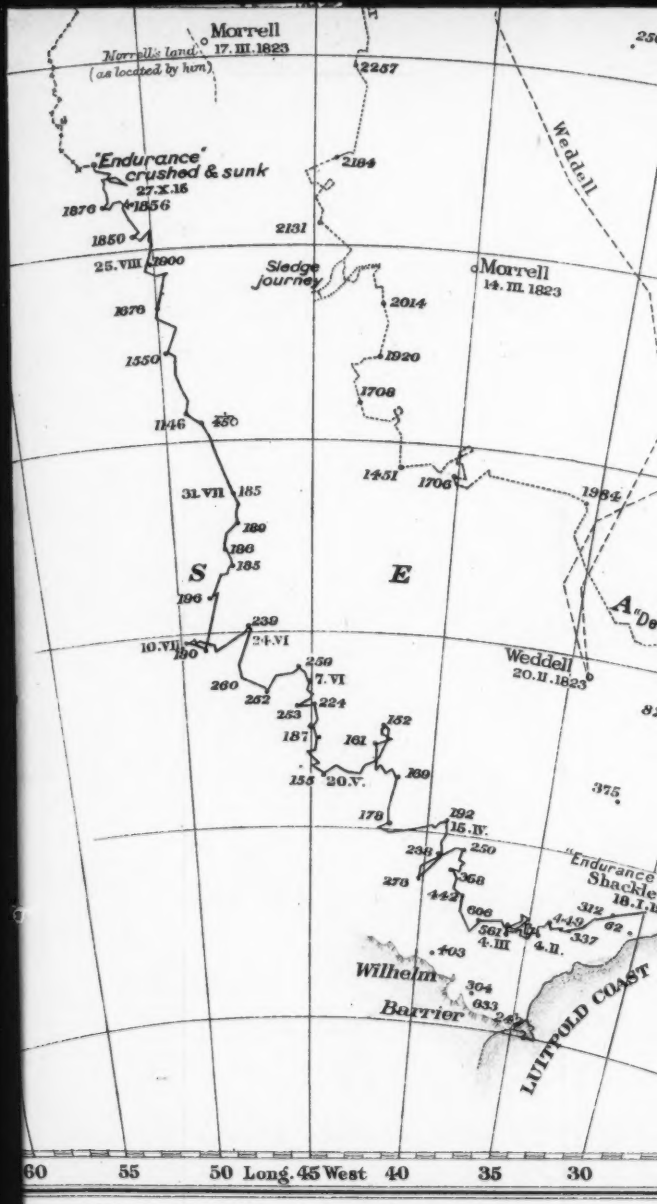
100 50 0 100 200 300
Kilometres.

Track of "Endurance" ——

Drift of Party after "Endurance" was crushed - - - - -

Soundings in fathoms

nical Projection with True Meridians and Errorless Parallels 63° & 77° Pu



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